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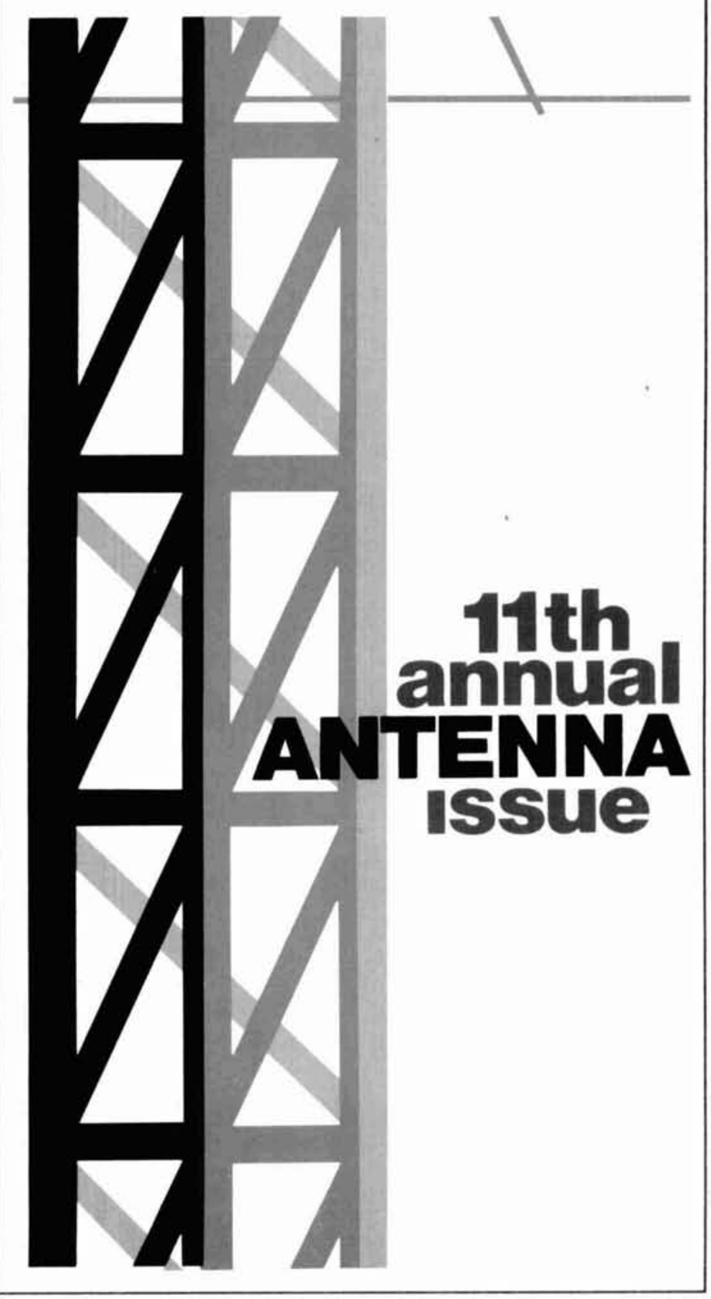
ham radio

magazine

MAY 1980



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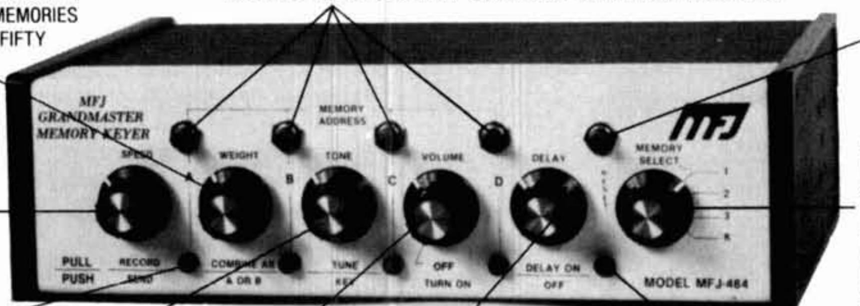

SPEED CONTROL, 8 TO 50 WPM. **PULL** TO RECORD.

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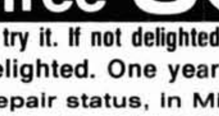

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More Details? CHECK—OFF Page 94

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magazine

MAY 1980
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a second look

by Jim Fisk

From time to time I am taken to task for editing a monthly Amateur Radio magazine that is "much too technical" and is written for radio engineers, not hams. I do not disagree with that premise in principle, only in degree — I feel strongly that most of our feature articles can be understood and applied by Amateurs who are interested in the technical aspects of radio: Amateurs who are still interested in the subtle details of designing their own circuits and building some of their own station accessories. Even with the great influx over the past couple of years of new Radio Amateurs who are primarily communicators with little technical knowledge, I believe the majority of licensed Amateurs still spend a large portion of their hobby time in their home workshops.

Subscribers who have been regular *ham radio* readers since I put together the first issue more than twelve years ago know that, from the beginning, *ham radio* has always placed the emphasis on radio theory and technique; operating news and views were left to others. Over the years we have tried to stay abreast of the state of the art, although at times this has been nearly impossible because of the great and rapid advances in developing technology. And, in general, when viewed in terms of the technology of the day, a better technical background is required now than it was ten years ago to understand a comparable level of circuit theory. The corollary, of course, is that what we consider to be unduly complex and difficult to understand in 1980 will likely seem relatively simple in 1990. This presents an interesting problem because as we continue to publish up-to-date radio circuits and projects, we run the danger of leaving a few dedicated readers behind. That is not our intent, and we shall make every effort to continue to appeal to as wide an audience as possible.

The microprocessor revolution has also greatly affected the technical content of *ham radio*, although not in the way you would expect; when most of the magazines jumped on the computer bandwagon, we continued to stress analog circuitry and presented only those computer topics that were closely related to radio communications. This has been highly popular, but many radio engineers and technicians who previously depended upon the industrial magazines for up-to-date design information became regular readers of *ham radio*; these are the same people who design the frequency-synthesized solid-state hf transceivers that are currently popular. Thus a dilemma: to publish up-to-date design articles that will ultimately improve the type of communications equipment we all have available, or continue to present decade-old technology to a 1980 world? Our answer has been a carefully chosen mix of established older techniques and complex new ones; when we stray too far one way or the other, we hear about it!

The continuing series on Yagi antenna design by W2PV which returns this month after a two-month hiatus is a good example of the type of article some readers feel is out of place; it explores antenna design and performance at a level normally reserved for engineering journals. If you've seen any engineering magazines lately, though, most of their articles are centered around microprocessor circuits; antenna articles are few and far between unless they're for satellite earth terminals. Those editors are appealing to a completely different market, so W2PV's Yagi series would be out of place — more important, it would not have been read by those people who are designing and building new high-gain antennas for the Amateur market. I feel we made the right decision when we accepted it for publication — it's likely to have more impact on high performance high-frequency antenna design than anything published in the last 20 years.

Jim Fisk, W1HR
editor-in-chief

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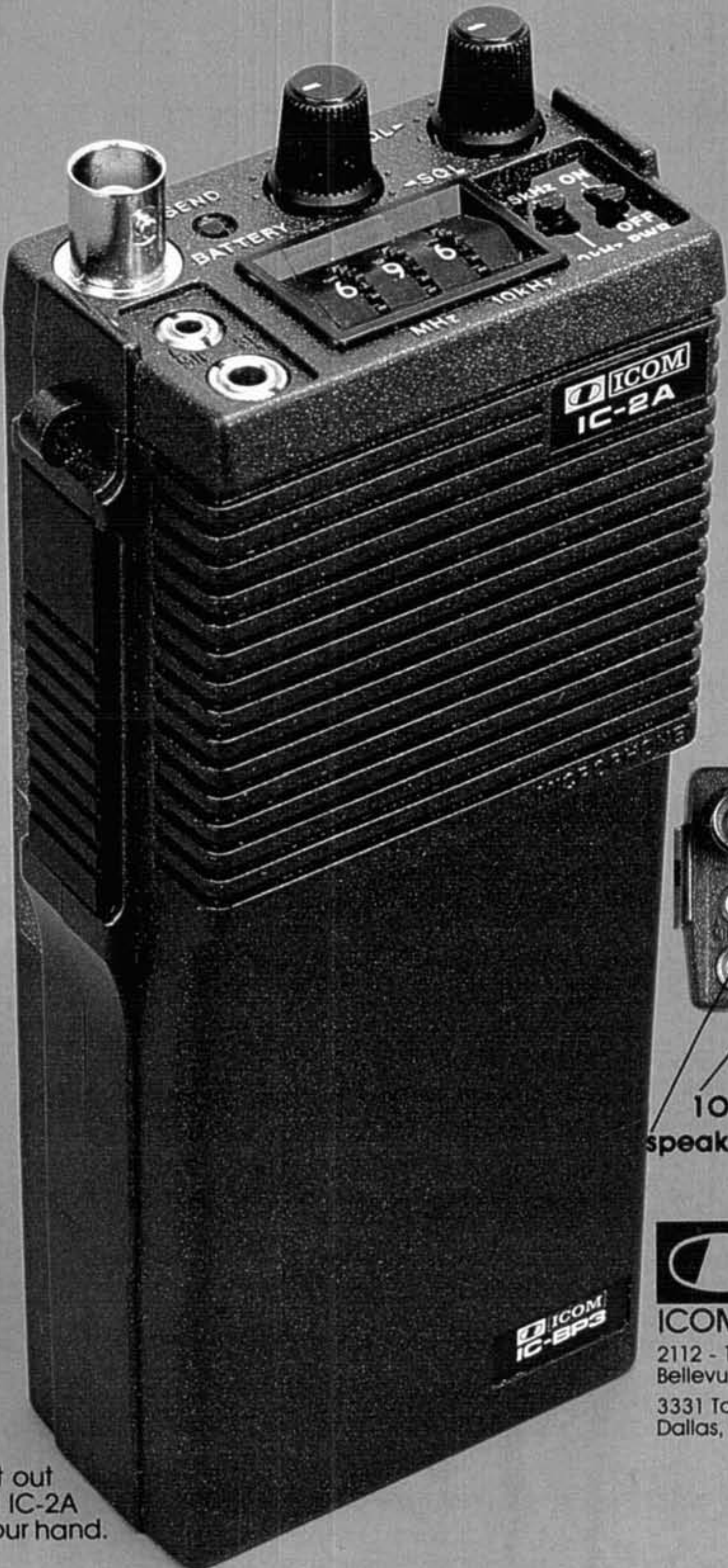

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comments

Hallicrafters story

Dear HR:

"The Hallicrafters Story" did not end with World War 2! Several years later, in Korea, the BC-610 transmitters — tired old rigs that they were — still carried the brunt of our radio communications during the early days of the Korean conflict. We of the Military Advisory Group in Korea inherited several BC-610s and a few SCR-399 rigs when the American Army of occupation left in 1949. When the invasion of south Korea started on June 25, 1950, we fired-off a SC-399 and established an emergency communications link with Tokyo.

When the Hahn river bridge was blown sky high two days later, one of our SCR-399 trucks was jammed in heavy traffic — on the north ramp of the bridge. On the south side of the river, I was operating another SCR-399 in contact with Tokyo. I heard the operator on the north side of the river and he was in contact with Tokyo, too (all on CW) but for some reason he couldn't hear my signals! He was telling Tokyo that the bridge had blown up in his face, the traffic jam was so bad that he might have to destroy the radio, and there were enemy tanks wandering around the city of Seoul! Then he went off the air; I figured we could scratch one radio, but Sgt. Francisco was not giving up so easy!

A few hours later he was back on the air — reporting that he had gotten the truck and trailer of his SCR-399 across the river on a barge! Now he was out of gasoline and the enemy was lobbing mortars at him! We rushed a jeep up the river with a couple of jerry-cans of gas, and a bit later the truck I never expected to see again pulled into our camp!

A few nights later we made a crash retreat south; there was a report that enemy tanks had gotten behind us and cut the roads, so we drove down trails so narrow that we scraped brush on both sides of the road. I operated my BC-610 mobile in motion all that night, and a radioman in Yokohama kept contact with me straight through!

During the battle for Taejon the choke in the high-voltage supply of my BC-610 went down to ground. We replaced it with a resistor and went right back on the air — with a real pretty note and a few more watts of power! (A Korean mechanic rewound the choke for us and it was still working two years later.)

The roads were so rough in Korea that wheel-bolts would sometimes crystalize and break off the trucks. Once a modulation transformer broke loose and wiped the whole audio deck clean — right down to reducing everything on the deck to dust! So what! We were operating all CW anyway, so we didn't miss the audio deck in our BC-610.

One night there was some kind of blackout, and the whole high-frequency band was just a hiss — not a signal to be heard; of course, that was the night the big brass had an urgent message that just had to get through! We fired off both SCR-399 rigs, one with a horizontal antenna, the other vertical, and we adjusted the frequency of one about 800 hertz off the frequency of the other, then keyed them both together; what a God-awful signal that made, but we got the message through. The only message that got through from all Korea that night!

Our SCR-399s served all through the Pusan perimeter days, went north when the breakout came, and made the long retreat back down the peninsula when the Chinese clobbered us. By the time the cease-fire came, we had added another ten-thousand hours to those old war-weary rigs left over from World War 2!

James Houldsworth, W1TVN
Pittsfield, Massachusetts

Dear HR:

I feel compelled to let you and Bill Orr know how much I enjoyed the "Hallicrafters Story" in the November *ham radio*. To most of us hams over the age of 50, the mere mention of the HT-4 brings back fond recollections. Some of us also spent time around the BC-610 during and after WWII, and during the golden years of military surplus that followed.

It was the kind of article that I could not lay down until I finished it, and I have read it a second time. Bill Orr should be commended for yet another very fine article.

Thanks again and keep up the good work.

Marshall B. Turner, KØADM
Parkville, Missouri

talking digital readout

Dear HR:

I want to congratulate you on the fine article, "Talking Digital Readout for Amateur Transceivers," in the June, 1979, issue. Pete Tanner, N5EJ, built one for Jerry Thomas, KA5GBP, who is blind, and it works great with his TS 120S. You are to be commended for providing this assistance to handicapped Amateurs.

Sammy Neal, N5AF
Cleveland, Texas

New
Fully Automatic Antenna Tuner
Auto-Track Model AT-2500

Check these state-of-the-art specifications

- Power Capability: 2500 W PEP
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More Details? CHECK—OFF Page 94

presstop

COMPLAINTS TO THE FCC ABOUT AMATEUR operations have tripled in the past year, and though the Amateur service is still considered to be probably the best in compliance of all the services administered by the Commission, this rapid increase signals a very alarming trend that shouldn't be allowed to continue. The increase lies principally in two areas; net operations on the hf bands, and on repeaters. In both areas the problem is mainly one of jamming, willful and deliberate interference, an area that's been widely publicized since Southern California Amateurs enlisted the aid of California Congressman James Corman last summer.

A Major Attack on the interference problem, concentrating in those two areas and likely enlisting the active aid of Amateur observers, is now being prepared within the FCC. Final details of the plan are now being worked out between the participating bureaus, and will be announced soon.

The Amateur Who Threatened the FCC engineers who were investigating his possible jamming activities in Los Angeles last fall has been indicted by a federal grand jury. John W. Munson, Jr., K6EOA, was jailed for 20 days in October as a result of that incident, but was released when the U.S. attorney in the case decided not to proceed on felony charges against him at that time. The two-part indictment was handed down in late March after the grand jury heard transcripts of transmissions from K6OEA such as "Hey, I wonder if I jam if I can get those guys to show up again" (after he'd refused FCC engineers a look at his station during a jamming investigation); "I'd like to shoot me a couple of feds."

EXISTING CLUB, RACES, and Military Recreation Amateur licenses should probably be retained, the Commissioners agreed at an Agenda meeting in March, but no new licenses of these classes should be issued in the future. During their deliberations the Commissioners weighed the alternatives of dropping the freeze on these licenses and accepting applications for new ones (too expensive) as well as doing away with them altogether. With only 611 RACES, 331 Military Recreation, and about 2000 Club licenses currently in force, annual cost to the FCC was estimated at only $1600, not unreasonable for the benefits of continuing them.

7.05-7.10 MHZ CANADIAN PHONE operation for Advanced Amateur class operators has been authorized by Canada's Department of Communications, causing severe problems for United States Amateurs trying to work DX phone stations just below 7.1 The DoC also approved F1 (frequency shift keying) between 3.5 and 28.1 MHz and A3 on 1.8 to 2.0 MHz for Canadian Amateur class certificate holders with six month's experience. New 902-928 MHz frequencies were added, while 420-430 MHz was deleted from Canadian Amateur allocations, and official sanction was given to the reciprocal "no permit" operating agreement.

U.S. Amateurs Operating In Canada must use "the callsign, radio frequencies, type of emissions, and modes of transmission he is authorized to use in his own country, if those frequencies, types of emissions, or modes of transmission are authorized by these (DoC) regulations."

A NEW SIBERIAN-BASED "WOODPECKER" has now been confirmed, transmitting a slightly different pulse pattern than his three more western brothers, and apparently located in the Kamchatka Peninsula area. It definitely points up much further east than the central Siberian woodpecker that came on last fall.

The European Woodpecker started a new transmission pattern in late March, with a 50-100 kHz wide signal and a 25-35 Hz pulse rate. It's been spending long periods on the low end of 10 meters between 1200 and 1400 UTC, and points up from the same area as the old European woodpecker.

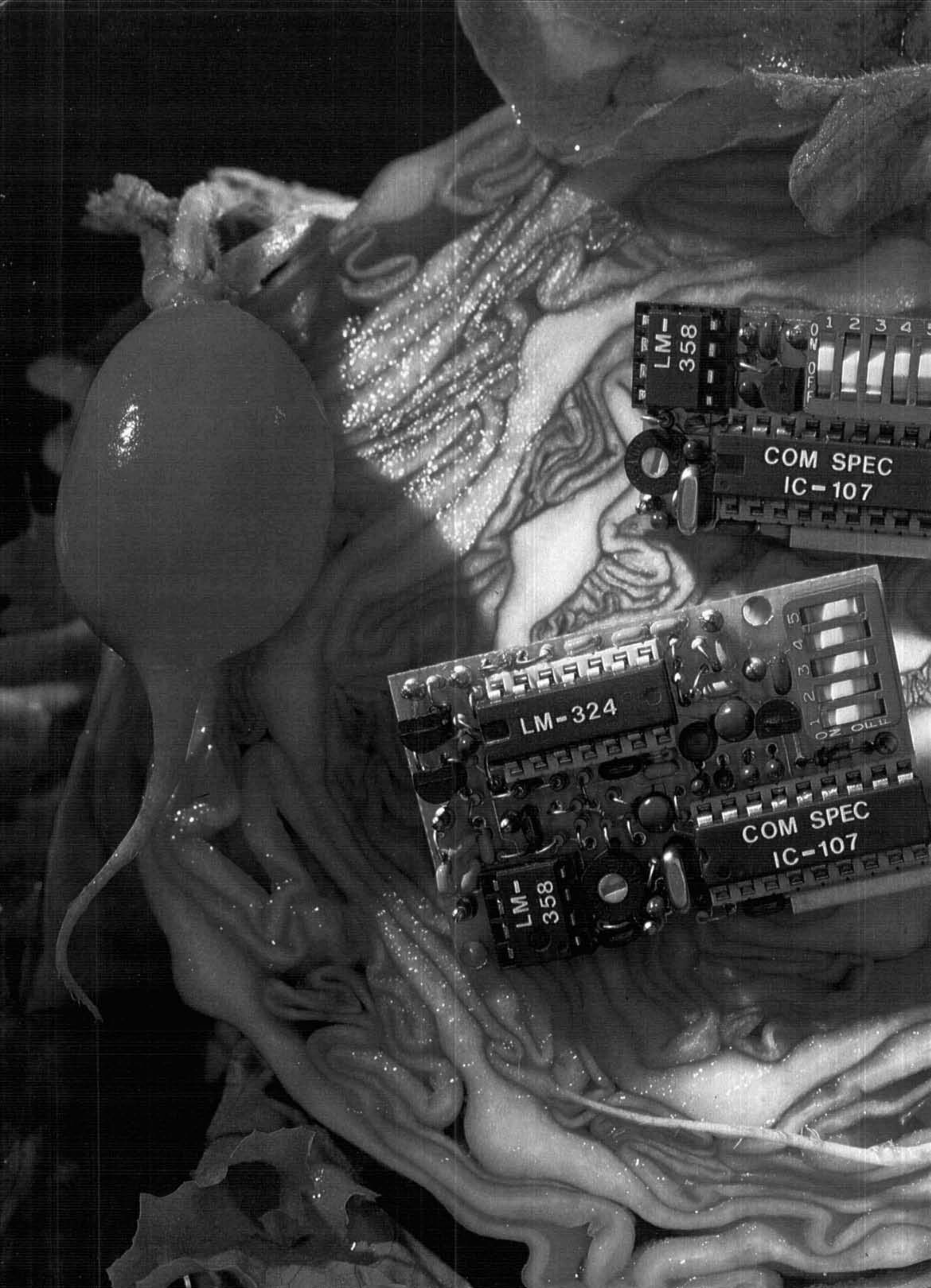
A Woodpecker Noise-Blanker circuit will be presented in the June issue of HAM RADIO. Designed by DJ7VY for receivers with a 9-MHz i-f, the circuit is not widely known outside Europe, where it was originally published two years ago.

A POTENTIALLY DEADLY THREAT exists in many hamshacks due to the PCB, the potent cancer-causing chemical widely used as a high-voltage insulator until a ban was imposed on its use by the Environmental Protection Agency. Polychlorinated biphenyls have been widely used in the manufacture of capacitors and transformers since the early 1930s, and many Amateurs are currently using PCB-filled capacitors in their high-voltage supplies without being aware of the potential hazard.

There Is No Danger so long as seals are intact, but exposure to liquid PCB seeping from a leaking capacitor could have grave health consequences for an Amateur or his family. Amateurs who suspect their oil-filled capacitors might contain PCB — GE's Pyranol is one well-known example — should check all seals carefully for leakage and make sure the capacitors are run well below their ratings to avoid stress.

Damaged Or Leaking PCB-Filled components should not be thrown in the garbage; it is illegal, in fact, to dispose of more than three pounds (one quart) of PCB except in a government-approved disposal site!

ART COLLINS, WØCXX, has been chosen to receive the Electronic Industries Association's Medal of Honor. Art, who started Collins Radio in his Cedar Rapids basement in the early 1930s, now heads Arthur A. Collins Corp. in Dallas doing R and D work in the communications field. Congratulations!



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- Size: 1.25" x 2.0" x .40"
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- Meets all new RS-220-A specifications
- Available in all 32 EIA standard CTCSS tones

SS-32 Encoder

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- Available with either Group A or Group B tones

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71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum −40°C to +85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

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TEST-TONES:	TOUCH-TONES:		BURST-TONES:			
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1000	770	1336	1650	1900	2200	2450
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three-element quad
for 15-20 meters which uses circular elements

Development of a circular-element quad beam from conception to final result — the *Dream Beam*

By J. W. Kennicott, W4OVO, 468 Colonial Drive, Lexington, Tennessee 38351

This project started in the winter of 1977-78 when I became active after having been off the air for over 40 years. I wanted a good antenna for 15 and 20 meters, but my location precluded a big beam. This article describes a quad antenna using circular elements rather than the usual square element configuration. Advantages of using circular rather than square elements are described together with construction details for building your own antenna. Development of the idea is discussed, beginning with a single-element circular antenna for 15 meters. The final version, a three-element circular quad, has given a good account of itself.

The idea was inspired by a bicycle wheel. Structural rigidity for the circular quad elements is provided by "spokes" radiating from the element hubs to the elements. Another bonus: the circular loop has a 0.9 dB gain over a square or diamond.[1]

May I now present the *Dream Beam*, its early development, model tests, construction, and performance.

early antennas

The first attempt was a very small model. The "bicycle" rim or tire (conductor) was made by springing a length of small-diameter stiff plastic tubing into a circle about two feet (0.6 meter) in diameter. The wheel hub was a 6-inch (153-mm) length of ¼-inch (6.5-mm) wood dowel with small plywood flanges on each end. Holes were drilled in the flanges all around, spaced at 45-degree intervals. Eight pairs of "spokes" were made from kite string connecting the "tire" in pairs to the holes in the hub flanges. Sure enough there was the wheel! It proved to be what I hoped for — very lightweight, surprisingly strong, resilient, simple, and a near perfect circle.

One-element circular quad loop for 15 meters. This work led to an attempt at a single-element, full-size antenna for 15 meters. The conductor for this antenna was 3/8-inch (9.5-mm) aluminum tubing lengths spliced together to a total length of about 46 feet (14 meters). This assembly was easily sprung into a circle, and the ends were attached to a feedpoint insulator that included an SO-239 coax connector. The hub was a 30-inch (765 mm) length of 1-inch (26-mm) PVC plastic pipe to which some end flanges had been fitted.

Eight pairs of spokes were used, which were made from 40-pound (18-kg) test monofilament nylon fish line. It did indeed look like a big bicycle wheel! It was about 15 feet (5 meters) in diameter, and I wondered if I could ever get it up into the vertical position. I gingerly picked it up by the hub and, to my pleasant surprise, found it quite stable and easy to handle. The whole element weighed only about 2½ pounds (1 kg) — so light that I could carry it up a ladder to the roof alone using one hand for myself and one for the antenna. The 15-meter antenna performed beautifully, and I used it for several months. It proved to my satisfaction that the construction principle was sound and would work.

One-element circular quad loop for 15-20 meters. A single-element 15 and 20 meter antenna was the next step. It was similar to the 15 meter version but quite a bit larger. About 70 feet (22 meters) of ½-inch (12.5-mm) aluminum tubing was sprung into a 22-foot (7-meter) diameter circle and connected with a similar feed point insulator. The hub was 4-foot-8-inch (1.4-meter) length of 1½-inch (38-mm) PVC pipe with flanges on each end. The number of spokes was increased to twelve pairs, and these were made from heavier 80 pound (36 kg) test monofilament nylon. The 15-meter element of no. 16 (1.3 mm) copper antenna wire was attached to the spokes in much the way a spider spins a web: rather than a true circle, it was a regular twelve-sided polygon. This antenna was a success and I worked much DX with it.

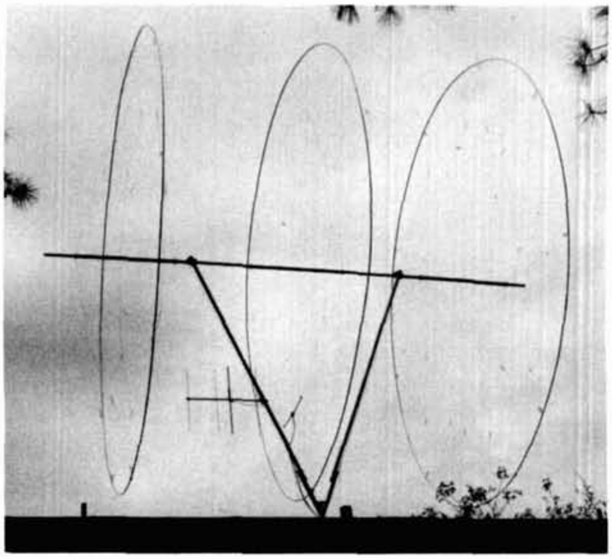
two-element beam for 15-20 meters

The two-element beam was a natural and easy development. Reflector elements were made just like the driven elements, except there were no feed-point insulators, of course. And did it work! I received excellent reports and many compliments on my signal from all over the world. I could usually contact any station I could hear. Europeans, ZLs, and VKs were worked with the greatest of ease and almost at will. It was a quiet receiving antenna and seemed to have excellent directional properties.

three-element beam for 15-20 meters

Then I began to think of installing a director. Would the antenna be further improved with a third element, a director? If so, could I get one up there? Yes, there might be a way, and I dreamed up the basics of the three-element version.

I was about to begin building when nagging doubts began to creep through my mind. The message said, "Look OM, you have a fine antenna now, but you really know very little about it. Do you know what the beamwidth is, what the pattern looks like, and whether you have the optimum reflector length and spacing? If you put up a director, what length will be best? What spacing will be optimum? What will the front-to-back ratio be? You really don't know these things. Enlarging the beam will take a lot of time and much work. You may fall flat on your face!" I had to agree. I decided to postpone the director and



The *Dream Beam* for 15 and 20 meters: like three giant bicycle wheels on one axle. The small 2-meter array (lower left center) gets a free ride.

embarked on a three-month period of model testing to find out where I was, where I wanted to go, and how I was going to get there.

model tests

In my backyard antenna range, a one-watt 2-meter carrier from a dipole illuminated the model antenna under test. Induced currents were observed and recorded and patterns plotted. After literally hundreds upon hundreds of patterns, I felt I had the answers to all the questions — plus much other valuable and interesting data.

One particularly interesting result concerns a very closely spaced two-element (driver and reflector) circular loop beam. If the reflector is made 1.018 times the length of the driven element and spaced at 0.065 wavelength, a very nice beam results. At 146 MHz this spacing is only about 5½ inches (140 mm). A beautiful 2-meter mobile beam antenna could be made using an aluminum loop driver. The reflector could be bracketed right to the driver with nonconducting material. You can't add a director to this arrangement; it will not work that way.

The model tests of the two-element configuration showed that I had been lucky. My earlier guesses at reflector length and spacing were reasonably close to optimum.

The bulk of the work was with the three-element configuration. Director and reflector lengths were varied, and the effects of various spacings investigated. The goal was to zero in on the optimum antenna. This was eventually done and the *Dream Beam* was made to the following dimensions:

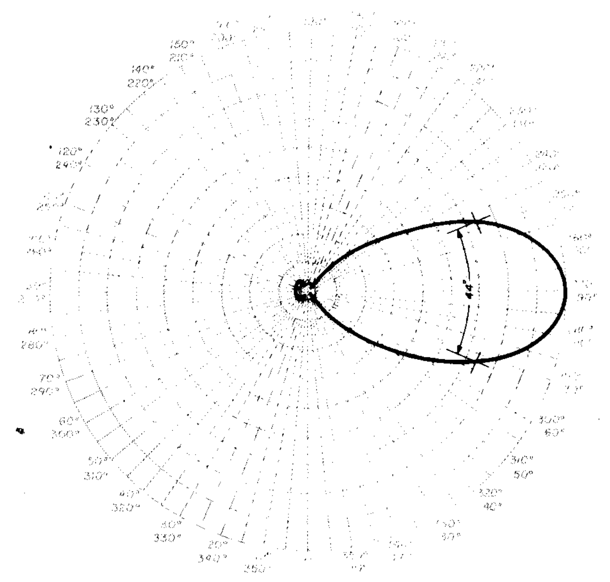


fig. 1. Horizontal radiation pattern of three-element, full-size circular loop beam at 145 MHz.

element lengths

14,275 kHz	**wavelength**	**feet**	**(meters)**
director element	0.977	67.34	(20.5)
director spacing	0.123	8.50	(2.6)
driven element	0.990	68.23	(21.0)
reflector spacing	0.123	8.50	(2.6)
reflector element	1.008	69.46	(21.2)
21,350 kHz			
director element	0.974	44.90	(14.0)
director spacing	0.141	6.50	(2.0)
driven element	0.987	45.50	(14.0)
reflector spacing	0.184	8.50	(2.6)
reflector element	1.005	46.30	(14.0)

You'll notice that the proportions of the 15-meter elements don't agree with those of the 20-meter elements. This comes about by mechanical considerations and the fact that it was necessary to tune the 15-meter element to resonance at 21,350 kHz. While the 15-meter array doesn't quite meet the optimum dimensions, only minimal harm comes from the dimensions used. The turning radius is only 14 feet (4 meters).

Fig. 1 is the horizontal pattern from model experiments. Numbers of vertical patterns were also made, and it always turned out that they were almost identical to the horizontal patterns.

impedance

The feedpoint impedance of a fullwave loop has been estimated to be in the range of 100-130 ohms. For the earlier one- and two-element antennas a very close match to 52-ohm coax was made with the use of quarter-wave matching sections of 75-ohm coax. In the three-element configuration the feed point impedance becomes much reduced. The impedance of the 20-meter driven element turned out to be about 20 ohms; the 15-meter element about 27 ohms. Excellent matches were made between the transmission lines and the antenna elements using matching stubs cut for these impedances.

circle versus rectangle

In general character there is much similarity between the *Dream Beam* and the familiar quad. Construction and configuration aside, there are some electrical differences. The resonant length of the circular configuration is somewhat less than that of the square or diamond. The resonant length of the circular loop is about $974/f$. The usual formula for the quad is $1005/f$. The parasitic element lengths are nearer to the length of the driven element in the case of circular loops. The director element is 1.3 per cent shorter; the reflector element is 1.7 per cent longer.

construction

To start at the bottom: A bearing and rotator are installed in the attic of my house. The installation is remarkably similar to the one described in detail by WØYBV.[2] He and I were perhaps cutting holes through our roofs at about the same time! The lower part of the Y-base (**fig. 2**) is a piece of 1½-inch (38-mm) steel pipe. To the top were welded two U-shaped steel members from a junk pile. They were just the right size and the V-struts were attached to them with U-bolts.

The V-struts are 12-foot (4-meter) lengths of 2-inch (51-mm) aluminum tubing. They are connected to the two 1½-inch (38-mm) diameter boom halves with U-bolts using tie plates cut from 1/8-inch (3-mm) aluminum sheet. This assembly must be carefully laid out so everything is in good alignment.

The 20-meter elements are made from lengths of 3/4-inch (9-mm) type 6061-T6 aluminum tubing. This tubing was flattened to make it something like an elliptical section about 15/16 inch (24 mm) wide and ½ inch (12.5 mm) thick. For the joints between sections, solid aluminum inserts were used. These inserts, 3/8 × ½ × 3 inches (9.5 × 12.5 × 77 mm), were fixed and connected by using no. 6 (M3.5) stainless steel machine screws. Spoke attach eyes are 3/32 × 1 inch (25 × 25.5 mm) stainless steel cotter pins in holes in the plane of the loops at proper intervals. Points are bent sharply back around the outside of the elements. The feedpoint insulator for the 20-meter driver is placed at the bottom. The SO-239 fitting mounted underneath was potted in silicone to make it watertight.

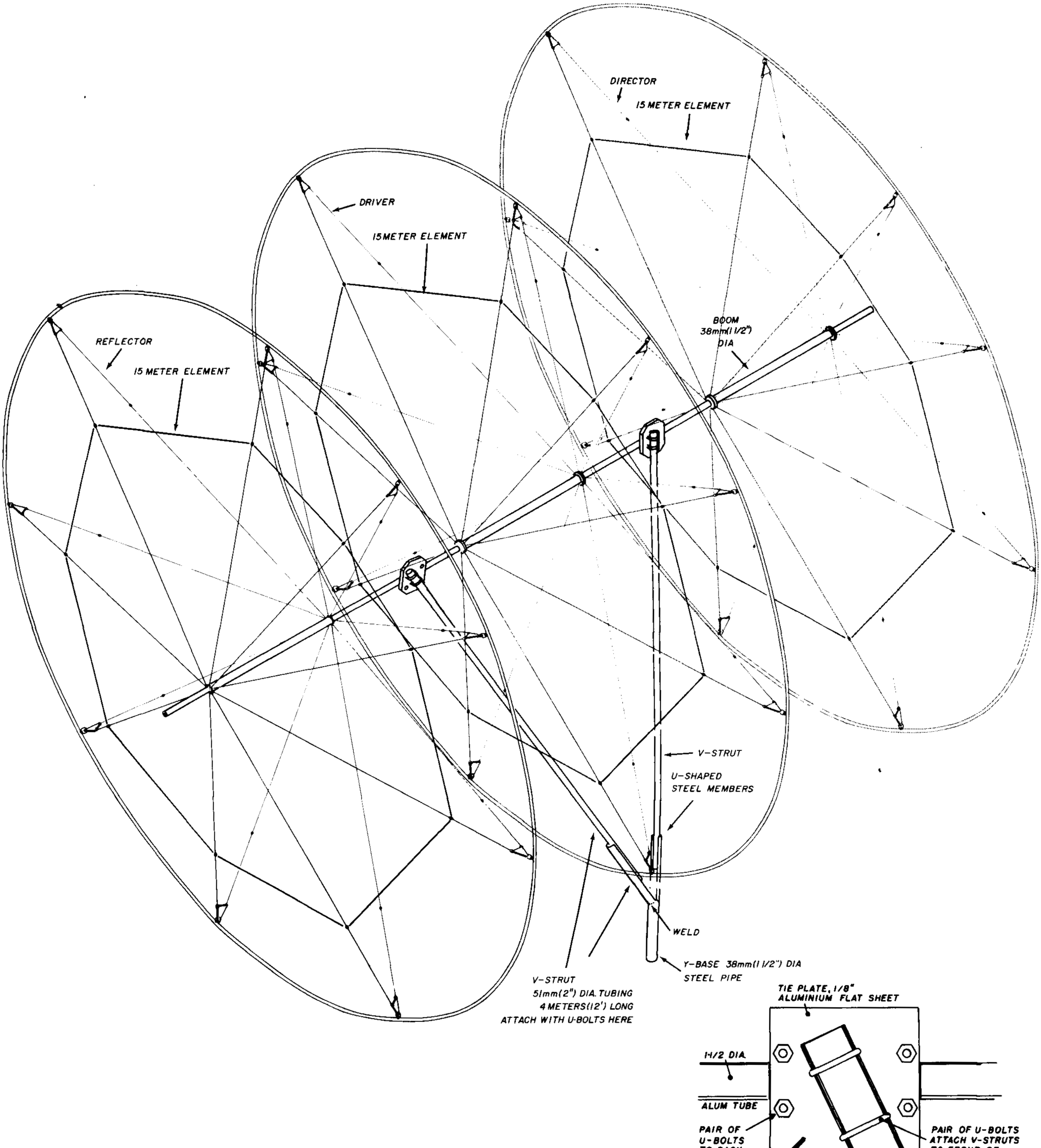


fig. 2. ***Above,*** **the** ***Dream Beam.*** **Although this antenna is similar to the quad, there are some electrical differences because the resonant length of this circular configuration is somewhat less than that of a square or diamond: for a circular loop, it's about 974/*f*, as opposed to 1005/*f* for the quad.** ***Below,*** **details of the boom/V-strut mounting bracket.**

The hubs are 6-foot (1.8-meter) lengths of 1½-inch (38-mm) schedule 40 PVC plastic pipe with spoke-attach flanges cemented on each end. Spoke-attach eyes are 1/8 × 1 inch (3 × 25.5 mm) stainless-steel cotter pins inserted in holes drilled through the flanges. Holes are parallel to the axis of the hub.

Nylon monofilament spokes in earlier antennas were not completely satisfactory. The *Dream Beam* elements have spokes of no. 20 (0.8 mm) stainless-steel wire. These are insulated, and nine pairs are spaced around at 40-degree intervals. Their lengths were calculated. They were made fairly accurately on a simple jig. This jig was a 12-foot (4-meter) length of 2 × 4 lumber with small finishing nails in it corresponding to the several points on the spokes. The element end of each pair of spokes is fitted with a 4-inch (102-mm) triangular insulator cut from a sheet of ¼-inch (6.5-mm) Lucite. The insulator is attached by a ¾-inch (19-mm) "key ring" to its spoke-attach eye. ("Key ring" is used for lack of knowing a better term. It consists of almost two turns of stiff, springy stainless wire and may be easily threaded onto and off of the attach eye. I got the key rings at a sailboat supply house, where they're called "cotter rings.")

In toward the hub another small plastic insulator is inserted in each spoke. These are ¼ × ½ × 4 inches (6.5 × 6.5 × 102 mm) long. There is a hole in each end to which the spoke is attached, and a hole in the center. The hole in the center is the eye through which the 15 meter element of no. 16 (1.3 mm) copper antenna wire is threaded. These elements become nine-sided regular polygons. These insulators must be accurately located (a nail in the jig) so that neat polygons of the correct perimeter result. The hub ends of the spokes are simply fixed to their attach eyes on the hubs. The flanges and hubs serve as insulation here.

handling

The elements may be assembled where there's sufficient room handy to the antenna location. Simply put them together. No jig or other special tooling is needed. They end up, completed, lying on the ground.

Handling and transport of the assembled elements at first appeared to present a tricky and complicated challenge. However, it turned out to be ridiculously simple, easy, and safe. A carrier was made like a grossly elongated T. The "up-and-down" portion is a 12-foot (4-meter) length of 1¼-inch (32-mm) light steel tubing. At the top, a 4-foot (1-meter) piece of tubing is attached across. Two clips were made from a piece of PVC pipe (somewhat larger then the hubs). The clips were cut so they could be snapped on and off the hubs with ease; they were bolted to the top of the T.

Simply clip the carrier onto the hub, pick up the element, and lift it to the vertical position. Superhuman strength and balance are not needed; after all, an element weighs only about 9 pounds (4 kg). I must admit to being a little frightened when I tried it for the first time. The 22-foot (7-meter) "wheel" looks gigantic when towering over your head! The purpose of the carrier, of course, is for transporting the element and slipping it onto the boom. The hub ID is about 3/32 inch (2.5 mm) greater than the 1½-inch (38-mm) boom, so it may be slipped on and off readily. When the hub is on the boom, give the carrier a downward jerk. The clips open and the carrier is separated. Elements went up and on, and off and down, many times during development for changes, adjustments, and pruning. Not the slightest difficulty was ever encountered.

assembly

Assembly of the entire array is really not so complex as it may at first seem. It was quite fun — a great satisfaction to see it up there, in place and "flying." I'm not exactly a spring chicken and don't claim the vision, balance, and agility of 30 or more years ago. The whole antenna was, however, assembled from the parts on the ground to their places in the rooftop array in about four hours. This work was done entirely alone with no assistance whatsoever.

Fig. 2 shows the various parts in relative positions. The key to the assembly of the structure is 20-foot (6-meter) length of 3/32-inch (2.5-mm) stainless-steel *flexible* cable. This is obtainable at most marine hardware dealers, particularly those handling sailboats and supplies. It is permanently attached to the *inside* of the left boom tube at the right end. Steps are as follows:

1. Position the steel **Y**-frame in tne bearing and rotator.

2. Run a 25-foot (8-meter) messenger of stout cord or fish line through the eyebolt in the left tie plate (used later for the reflector preventer cord). Erect the left V-strut and boom half, securing it to the Y-frame with U-bolts.

3. Run a 25-foot (8-meter) messenger through the hub of the driven element. Bring the driven element into position, ready to slip onto the left boom half. Connect the flexible cable to this messenger and pull it through the hub of the driven element so it comes out on the right. Slip the driven element onto the left boom half.

4. Drill a 3/8-inch (9.5-mm) hole in the bottom of the right boom half near where it is attached to the V-strut. Run a 25-foot (8-meter) messenger (for the flexible cable) through this hole so that it comes out from this boom half on the left.

5. Run a 25-foot (8-meter) messenger through the eyebolt in the right tie plate (used later for the director preventer cord). Connect the flexible cable to its messenger. Pull the flexible cable into the right boom half so that it comes out through the 3/8-inch (9.5-mm) hole. Slip the right boom half into the driven-element hub and secure this V-strut to the Y-frame with U-bolts.

6. Pull the flexible cable tight and fasten it securely to the Y-frame. The structure is now erected. The hub of the driven element acts as a sleeve connecting the boom halves. The flexible cable holds them tightly together inside the hub.

7. Slip on the reflector element. Connect the preventer cord (1/8-inch or 3-mm high-grade nylon parachute cord) to its messenger and pull it through the eyebolt in the tie plate, securing it to the Y-frame. This preventer cord simply restrains the element from sliding off the boom.

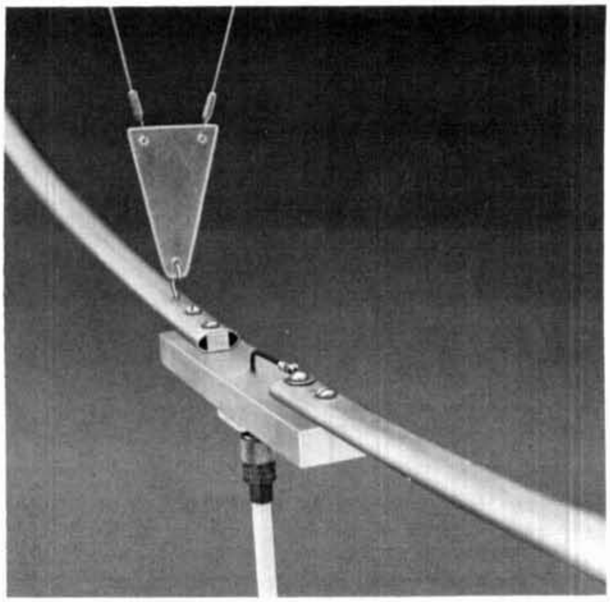
8. Slip the director element on in the same manner as the reflector.

disadvantages

The only disadvantage of this array is in the sheer size of the element assemblies. Once it's put together in your yard or patio, the only possible thing you can do with them is put them up where they belong. They are too large to ship by any means. They won't fit in your garage or basement, so they can't be stored away — unless you happen to have a vacant airplane hangar! They could be disassembled for shipping or storing, but not nearly so readily as with other beams.

serviceability

Only high-grade corrosion resistant materials were used. The PVC hubs were painted with polyurethane to avoid deterioration by sunlight. The antenna has satisfactorily survived two rather severe winter icings. Being somewhat resilient, the elements swing and sway in a gusty wind, but the array has withstood quite a number of very high winds in thunderstorms. As the array is mounted just above the rooftop, it's centered only about 30 feet (9 meters) above the ground. Some protection occurs from numerous tall trees in the area. I can't say how the array would do atop an 80-foot (24-meter) tower. The exposed area of each loop is 3 square feet (0.3 square meters). Further experience may show up weaknesses not anticipated.



How the feedpoint insulator is made and connected to the 20-meter driven element. The triangular-shaped insulator is between the circular conductor and the wire spokes. Portions of the Y-frame are visible, and the lower end of the V-strut can be seen.

performance

Evaluation of antenna performance is both difficult and perilous. The difficulty lies in the large number of uncontrollable variables, which render numerical comparisons very questionable. The peril is in one's ability to enforce strict self-discipline and maintain a truly objective viewpoint. It's easy and tempting to overrate something which is your own baby, your own creation.

In the past year every opportunity for evaluation and comparison has been seized; this process is still going on. Reports and results have been extremely encouraging, and I become more pleased and confident as the hard evidence comes in day by day and week by week. Much of the time I get reports such as: "You are very, very strong;" You have the strongest signal on the band;" and, "Your signal is 15 to 20 dB over S9." Some of the reports have been so good as to be not believable. I can't remember when another station couldn't read me if I could read him. Being picked out the first time in DX pileups has become fairly common. Though many long months in coming, the *Dream Beam* is now a reality.

reference

1. Frank Witt, W1DTV, "Simplified Antenna Gain Calculations," *ham radio*, May, 1978, pages 78-85.

2. Charles J. Ellis, WØYBV, "A Novel Way to Mount a Rotary-Beam Antenna," *QST*, May, 1979, pages 32-33.

ham radio

Yagi antenna design:

performance of multi-element simplistic beams

A Yagi antenna can be characterized by one or more driver elements and a number of parasite elements, all supported on a boom.

For each element we must specify X and Y coordinates, a length (LE), a radius (RO), all measured in terms of (central) wavelength, and in the case of each driver, the excitation potential (V) or current (I) and its phase referred to some time standard.[1]

It is instantly apparent that with all of these variables an exhaustive investigation into all possible configurations is impractical! Instead I shall begin with an initial consideration of "simple" or simplistic Yagi antennas and will subsequently discuss a variety of departures from this simplistic design. I will define this (simple) class of Yagi antennas as those involving a single driven element with one or more parasitic elements. No more than one "reflector" will exist, and all "directors," if any, will be uniform, i.e., they will have identical lengths and diameters. Moreover, all elements will be uniformly spaced along the boom. Additionally, the antenna will be in *free space*; we shall initially investigate only free-space performance properties.

These restrictions may seem at first sight to be quite severe, but I hasten to remark that free-space performance will relate to actual performance over ground or earth (to be discussed in a later article) and the simplistic Yagi antenna, as defined above, can, in many instances, provide performance levels fully as good as those from more sophisticated designs. Furthermore, we can learn a great deal about Yagi antenna performance from studying these simple designs and, as we shall see, will develop useful conceptual ideas about Yagi behavior and ideas for "best" design.

Throughout this investigation of simplistic antennas I will choose element dimensions (radii) characteristic of "normal" 14 MHz construction ($RO = 0.000526\ \lambda$). The results can be translated to any other element dimension by proper scaling calculations; scaling rules will be given later.

two-element beams

I shall begin with a 2-element Yagi beam involving one parasite which can act either as a "reflector" (for frequencies above its resonance) or as a "director." For such a beam there are only two fundamental variables: The physical separation of the two elements along the boom and the physical length of the parasite! The exact length of the driven element is of little consequence as far as gain and pattern are concerned; it does, however, affect driving-point impedance (especially reactance) which is considered later. Since we shall be interested first in a frequency swept plot of the gain and F/B properties, the physical length of the parasite can be fixed; as we increase the frequency from well below to well above the parasite free-space resonant frequency we can observe the properties of the beam first where the parasite behaves as a director and secondly as a parasitic reflector.

The computation methodology I shall use is that given explicitly in an earlier article.[1] In all cases of the 2-element beam I have used a cylindrical length, $LE = 0.48167\ \lambda_o$, and a radius, $RO = 0.0005260\ \lambda_o$ for both parasite and driver; this makes each element's isolated free-space resonant frequency, FR, equal to unity on the normalized frequency, F, scale, where $F = f/f_o = 1$. The frequency itself is varied in steps

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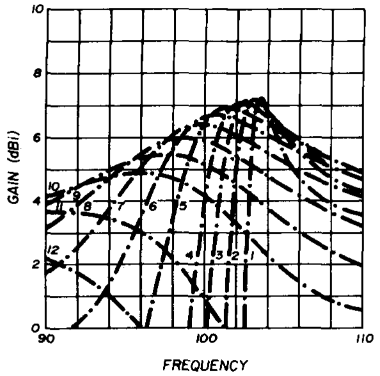


Curve	S	Curve	S	Curve	S
1	0.025	5	0.150	9	0.350
2	0.050	6	0.200	10	0.400
3	0.075	7	0.250	11	0.500
4	0.100	8	0.300	12	0.600

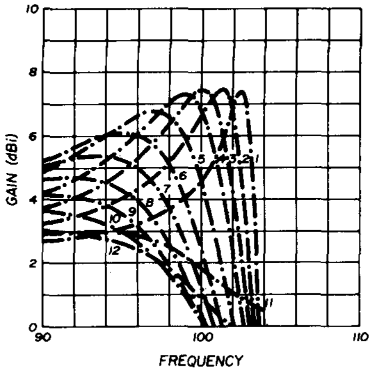
fig. 1. Frequency swept gain plots of 2-element Yagi antennas with different element spacings, S, where the parasitic element acts as a *reflector*.

from about 90 per cent ($F = 0.9$) to 110 per cent ($F = 1.10$) of the central frequency ($F = 1.0$); these steps were made sufficiently small to fully show the behavior of the beam. Element separation, S, measured in wavelengths at the central frequency, f_o, is varied from 0.025 to 0.5, again in steps sufficiently small to bring out essential behavior.

Fig. 1 shows the frequency swept gain of the 2-element Yagi antenna for several element spacings, S, where the gain is positive in the direction of parasite towards driver, i.e., where the parasite acts like a reflector! Each curve represents a particular spacing, S, appropriately keyed in the legend. **Fig. 2** is a similar frequency swept plot of the free space *F*ront-to-*B*ack ratio, F/B, for the same series of element separations, S. **Figs. 3** and **4**, in the same format, show the gain and F/B where the parasite acts like a director, i.e., where the gain is positive in the direction of driver towards parasite!

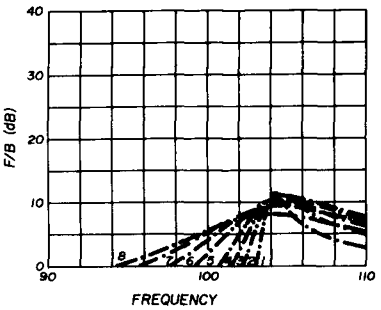
Examination of these performance plots, together with additional information on computed driver input impedance, reveals a number of interesting facets of the behavior of 2-element Yagi beams. First I show in **fig. 5** a plot of the gain at central frequency ($F = 1$) only as a function of element spacing, S. This is similar but not identical with a plot shown on page 147 of the *ARRL Antenna Book*;[2] it is possible that the differences, particularly at small spacings, are due to greater precision in the new calculations. In any case, I believe the implications of this plot may be somewhat misleading!

You can easily see that the *maximum* gain(s) obtainable at the "best" frequency(s) in **figs. 1** to **4** look somewhat different! These are shown in **figs. 6**



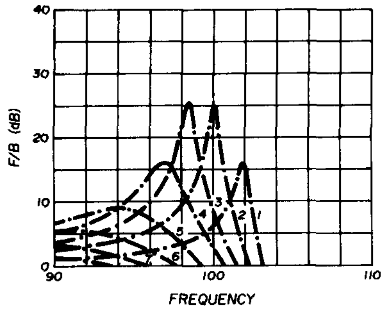
Curve	S	Curve	S	Curve	S
1	0.025	5	0.150	9	0.350
2	0.050	6	0.200	10	0.400
3	0.075	7	0.250	11	0.500
4	0.100	8	0.300	12	0.600

fig. 3. Frequency swept gain plots of 2-element Yagi antennas with different element spacings, S, where the parasitic element acts as a *director*.



Curve	S	Curve	S
1	0.025	4	0.100
2	0.050	5	0.150
3	0.075	6	0.200

fig. 2. Free-space front-to-back ratio for the 2-element Yagis vs different element spacings, S (parasitic element acting as a *reflector*).



Curve	S	Curve	S
1	0.025	4	0.100
2	0.050	5	0.150
3	0.075	6	0.200

fig. 4. Free-space front-to-back ratio for 2-element Yagis vs different element spacings, S, (parasitic element acting as a *director*).

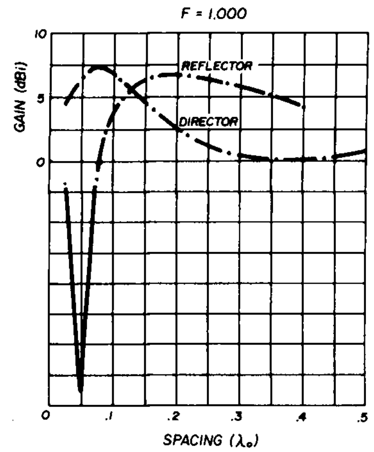


fig. 5. Plot of gain of a 2-element Yagi at central frequency (F = 1) as a function of element spacing S.

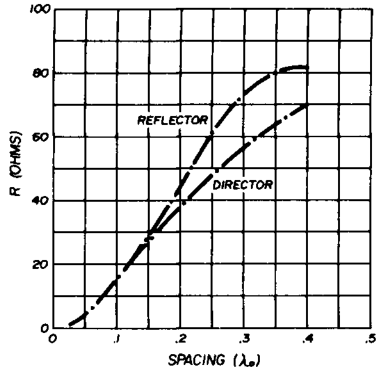


fig. 8. Driving point resistance of a 2-element Yagi vs element spacing.

and **7**, where for reference the curve for $F = 1.0$ is also shown. You can see that the obtainable gain does *not* depend greatly on whether the parasite is a reflector or a director as implied in **fig. 5**; moreover, the largest gain is obtained at very *small* spacings! This is a result which is not intuitive. **Figs. 6** and **7** can be compared with the early analysis by Brown,[3] and there appears to be good agreement. However, the result shown on page 146 of the *ARRL Antenna Book* which cites Brown's analysis is somewhat different. The fall off in maximum gain for low spacings shown by the ARRL reference does not appear to agree with Brown nor does it substantiate the calculations I have made (**figs. 6** and **7**).

If you examine the maximum gain(s) shown in **figs. 1** and **3** for best frequency and corresponding (driver) driving-point impedance, you obtain the values shown in **table 1**. A plot of R is shown in **fig. 8** which can be compared with a similar diagram shown on page 147 of the *ARRL Antenna Book*;[2] except for low values of S, agreement is fairly satisfactory.

You can see from **table 1** and **fig. 8** that element spacing affects (driver) driving-point resistance, and, therefore, circuit loaded Q (Q_L) over a *very* large range! This factor, as well as the gain curves shown in **figs. 1** and **3** set a practical limit to the achievable gain over a desirable bandwidth, e.g., perhaps 4 per cent in F. Moreover, the higher values of (radiation) loaded Q will, in practice, cause circuit resistive losses to be large and therefore the antenna efficiency to be low! Thus, in practice, really short booms are *not* very desirable; one must choose between efficiency and bandwidth on the one hand, and gain and F/B ratio on the other!

Long booms, however, also appear undesirable because gain really falls off (primarily due to reduced excitation of the parasite). Furthermore, for booms longer than 0.3λ a new phenomenon can be seen from a detailed computational analysis (not shown here). The front lobe of radiation begins to "dimple" in the forward direction, resulting in a pattern where the gain maximum occurs at an elevation angle other than zero with respect to the boom direction. (The gain shown in **figs. 1** to **4**, however, is just the energy flux in the direction of the boom referenced to

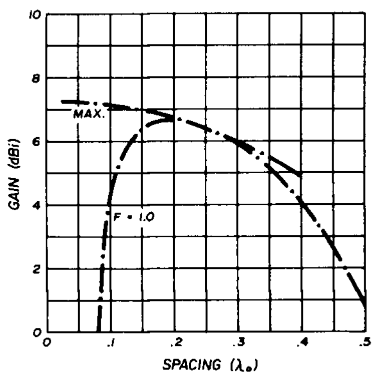


fig. 6. Gain of a 2-element Yagi vs element spacing; parasite a *reflector*.

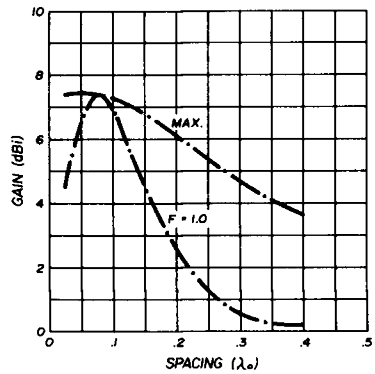


fig. 7. Gain of a 2-element Yagi vs element spacing; parasite a *director*.

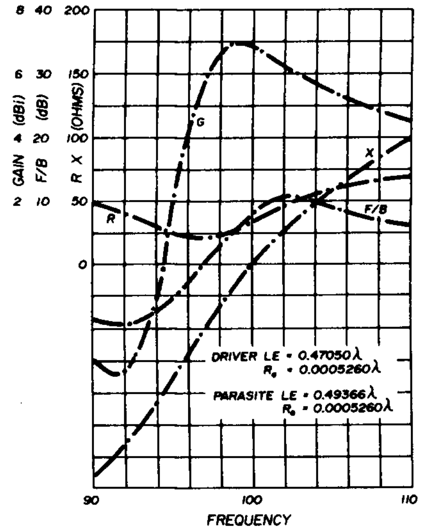


fig. 9. Gain, front-to-back ratio (*F/B*), and feedpoint impedance (*R* and *X*) as a function of frequency for a 2-element Yagi (parasite as a *reflector*). $S = 0.15\lambda$ at central frequency.

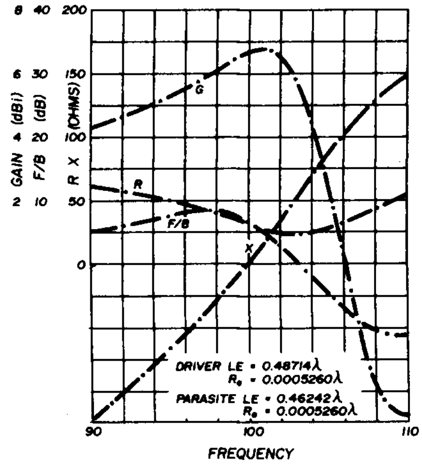


fig. 10. Gain, front-to-back ratio (*F/B*), and feedpoint impedance (*R* and *X*) as a function of frequency for a 2-element Yagi (parasite as a *director*). $S = 0.15\lambda$ at central frequency.

an isotropic radiator.) This pattern effect was predicted by Brown[3] and shown in Kraus, page 294.[4]

Note that the 2-element Yagi gives respectable performance in gain for a wide range of element separations! However, the *F/B* figures are not especially impressive; moreover best *F/B* does not occur at the same frequency as best gain! Thus, in designing a 2-element Yagi beam a practical compromise is necessary. If you wish to obtain good gain with at least a fair *F/B* ratio over a bandwidth of say 4 per cent, you can determine by inspection of **figs. 1** through **4** and **table 1** that a 2-element beam should have a boom length of perhaps 0.15 wavelength. For such a boom the gain is essentially independent of whether the parasite is a reflector or a director; moreover, the *F/B* is about equivalent for either situation.

To move the peak of the gain curve(s) in **figs. 1** to **4** to center frequency, the parasite length is adjusted commensurately; to reduce central frequency (driver) reactance, the driver length is adjusted.

These characteristics of 2-element beams are shown in **figs. 9** and **10** with a frequency-swept plot of each design. Note that each of these figures show gain, *F/B*, *R* and *X* of the driver. They illustrate the kind of design compromises which must be made. They also show the frequency-swept behavior of the main performance parameters.

The "best" central frequency is a matter of choice and is a compromise between gain and *F/B* ratio; it is adjusted by the length of the parasite. The (driver) driving point resistance and reactance vary significantly with frequency! Note that you cannot generally specify "a" resistance except at a single frequency such as the central design frequency; also note that

table 1. Maximum gain and feed-point impedance of a 2-element Yagi at various element spacings.

	reflector					director				
S	dBi max. gain	at freq.	R ohms	X ohms	Q_L	dBi max. gain	at freq.	R ohms	X ohms	Q_L
0.025	7.244	1.036	1.115	11.163	924.90	7.410	1.026	1.091	−10.029	1003.00
0.050	7.218	1.032	4.216	20.371	237.30	7.461	1.014	4.108	−17.556	265.50
0.075	7.158	1.030	9.679	31.834	99.13	7.417	1.000	9.801	−29.917	104.74
0.100	7.122	1.025	15.551	35.778	59.66	7.300	0.990	15.253	−34.122	63.03
0.150	6.964	1.015	29.577	38.574	28.90	6.800	0.970	27.452	−44.157	30.56
0.200	6.722	1.005	44.625	34.700	17.38	6.115	0.955	37.979	−49.407	20.64
0.250	6.406	1.000	61.400	31.612	11.01	5.383	0.940	48.183	−59.362	15.28
0.300	5.999	0.990	72.656	16.936	8.37	4.722	0.920	57.242	−80.457	12.27
0.350	5.491	0.980	80.527	−0.378	6.89	4.159	0.900	64.194	−104.165	10.62
0.400	4.913	0.960	81.957	−29.152	6.86	3.688	0.900	70.739	−103.310	9.24

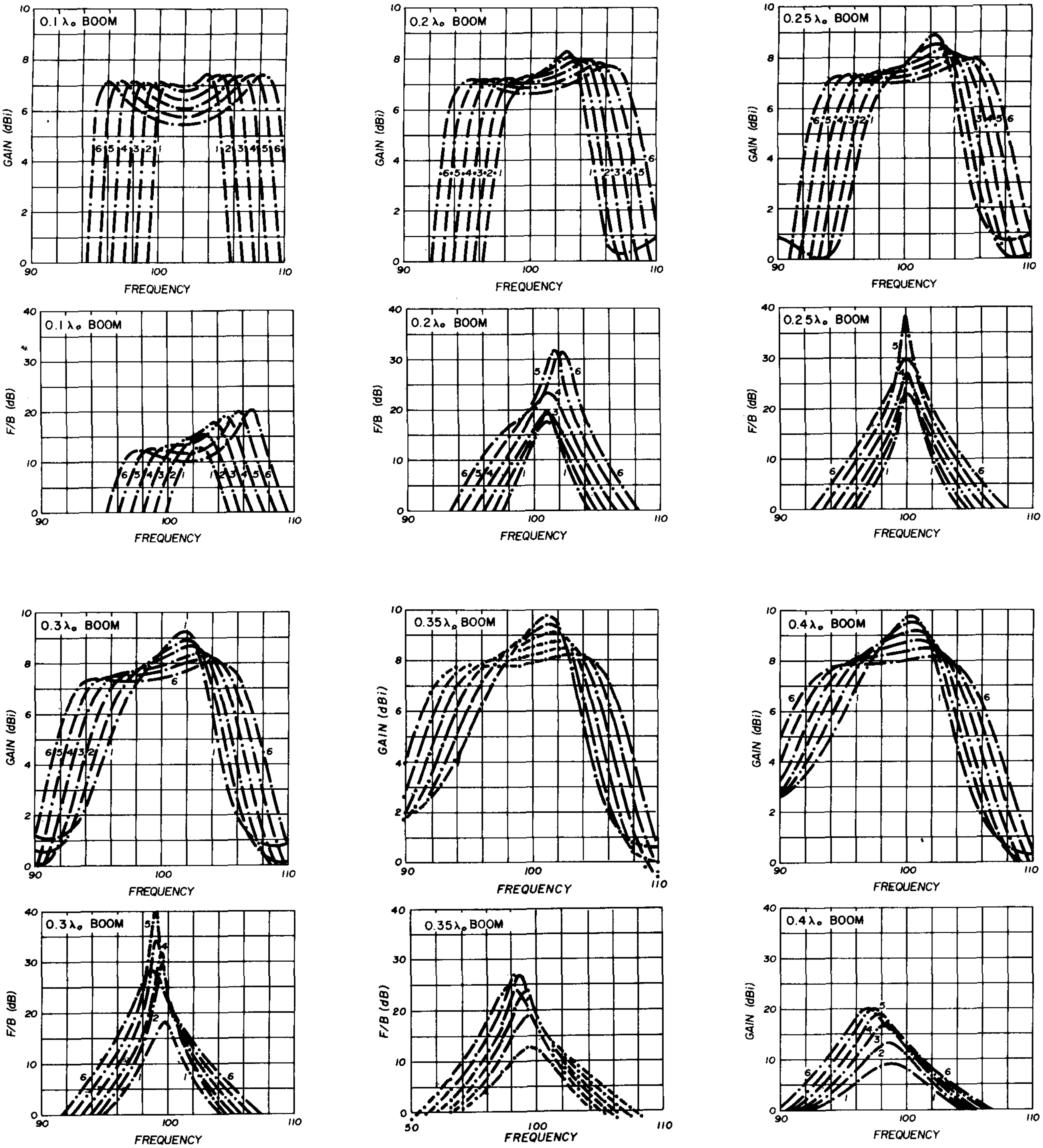
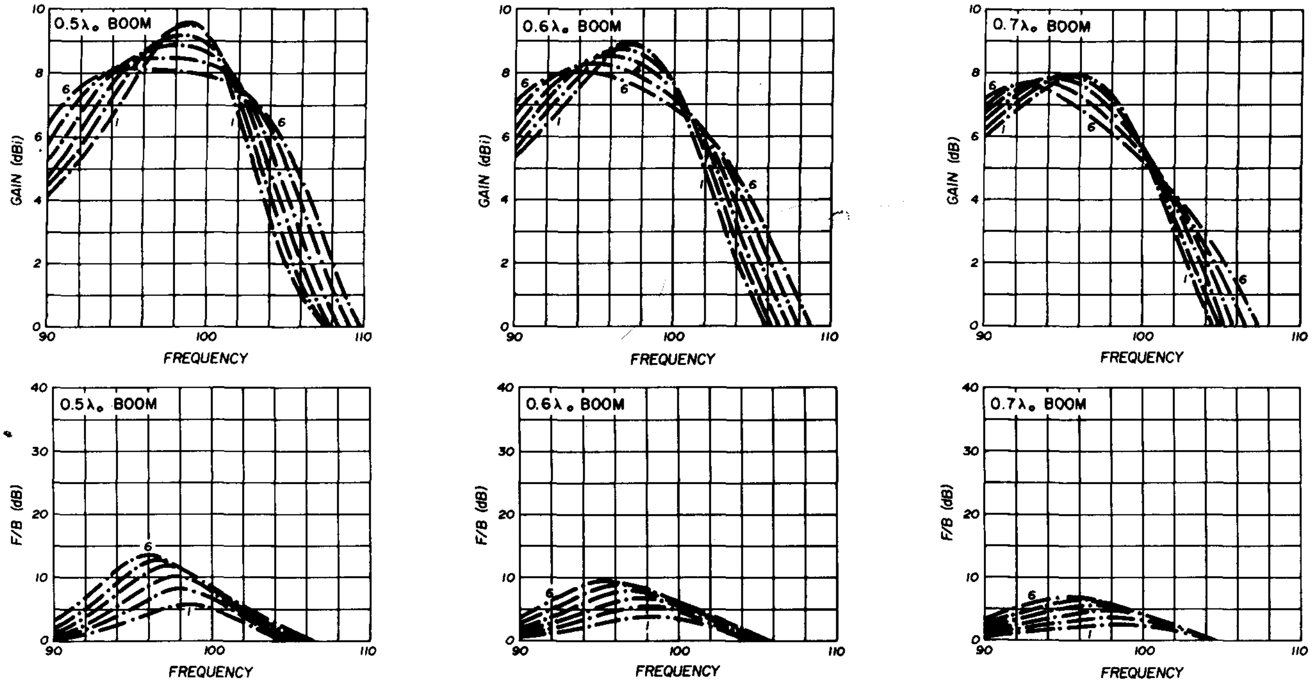


fig. 11. Gain and front-to-back (F/B) ratio for three-element Yagi beams with varying boom lengths, and changing reflector and director lengths (see table 3 for complete data). Boom lengths from $0.1\lambda_o$ to $0.4\lambda_o$. See next page for boom lengths from $0.5\lambda_o$ to $0.7\lambda_o$.

feedpoint reactance is not a linear function of frequency. This is caused by the combined effect of self and mutual impedance of the elements.

You can adjust the frequency of the zero reactance point by the exact length of the driver; this has been done only approximately in **figs. 9** and **10**. However, note that the adjusted driver lengths are quite *different* for the two cases, and each driver length is also different than the length for a single isolated resonant dipole in free space! These differences are again caused by mutual reactance coupled into the driver by the parasite.



Gain and front-to-back (F/B) ratio for three-element Yagi beams; boom lengths from $0.5\lambda_o$ to $0.7\lambda_o$.

table 2. Yagi antenna parameters and range over which one has been varied for this study.

parameter	range of exploration/display
Number of elements, N	$N = 3, 4, 5, 6, 7$
Boom length, ℓ_B	Generally up to 1.5λ
Reflector	$f_R = 0.98$ to 0.93
Director	$f_R = 1.02$ to 1.07

more than two elements

I will now turn to an analysis of simplistic Yagi antennas having more than one parasite. In all cases there will be only one reflector and all directors will have identical lengths. All elements are uniformly spaced along the boom. I shall display for clarity only the essential frequency-swept gain and frequency-swept F/B behaviors; the driving point impedances, all of which were computed, are of secondary interest at this point. For these Yagi antennas there are a number of parameters which should be systematically explored. **Table 2** shows these parameters and the range over which each has been varied. To display results in a consistent way I have chosen for each frequency-swept plot a fixed number of elements and a fixed overall boom length, ℓ_B, measured in wavelengths at the central frequency. On each plot there are six numbered curves; each number designates a particular parasite "tuning" combination; these combinations are shown in **table 3**. The lengths and free space resonant frequencies of parasites are shown for each numbered combination.

The curves of **fig. 11** show the results for 3-element beams as boom lengths, ℓ_B, are varied from 0.100 to 0.700 wavelengths. It is apparent from an inspection of these plots that the performance is superior to that of the 2-element beams; this is especially true in the F/B ratio. As you increase boom length the maximum gain increases (unlike that for 2-element beams); the F/B increases spectacularly, then decreases again. For this class of Yagi antennas there seems to be a *best* boom length; we shall see this kind of result for all of the simplistic Yagis and the physical explanation will soon be apparent!

Note that the chief parameter controlling the bandwidth over which gain remains high is the (resonant)

table 3. List of parasitic lengths and resonance in terms of the center frequency for the six numbered curves on each of the graphs of antenna gain and F/B ratio (figs. 11 and 12).

	reflector		director(s)	
curve	length	resonance	length	resonance
1	0.49150λ	0.98	0.47223λ	1.02
2	0.49657λ	0.97	0.46764λ	1.03
3	0.50174λ	0.96	0.46314λ	1.04
4	0.50702λ	0.95	0.45873λ	1.05
5	0.51241λ	0.94	0.45441λ	1.06
6	0.51792λ	0.93	0.45016λ	1.07

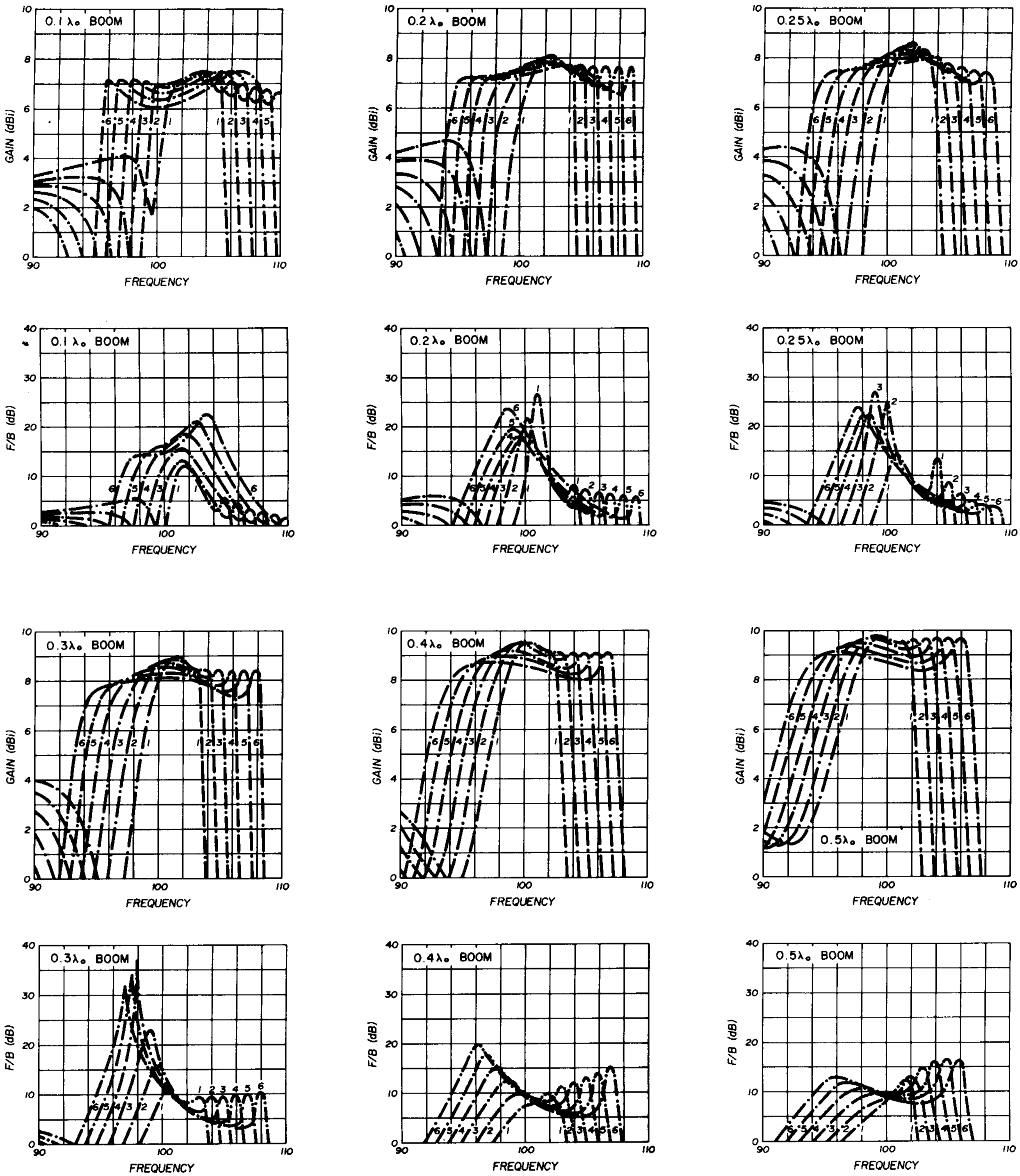
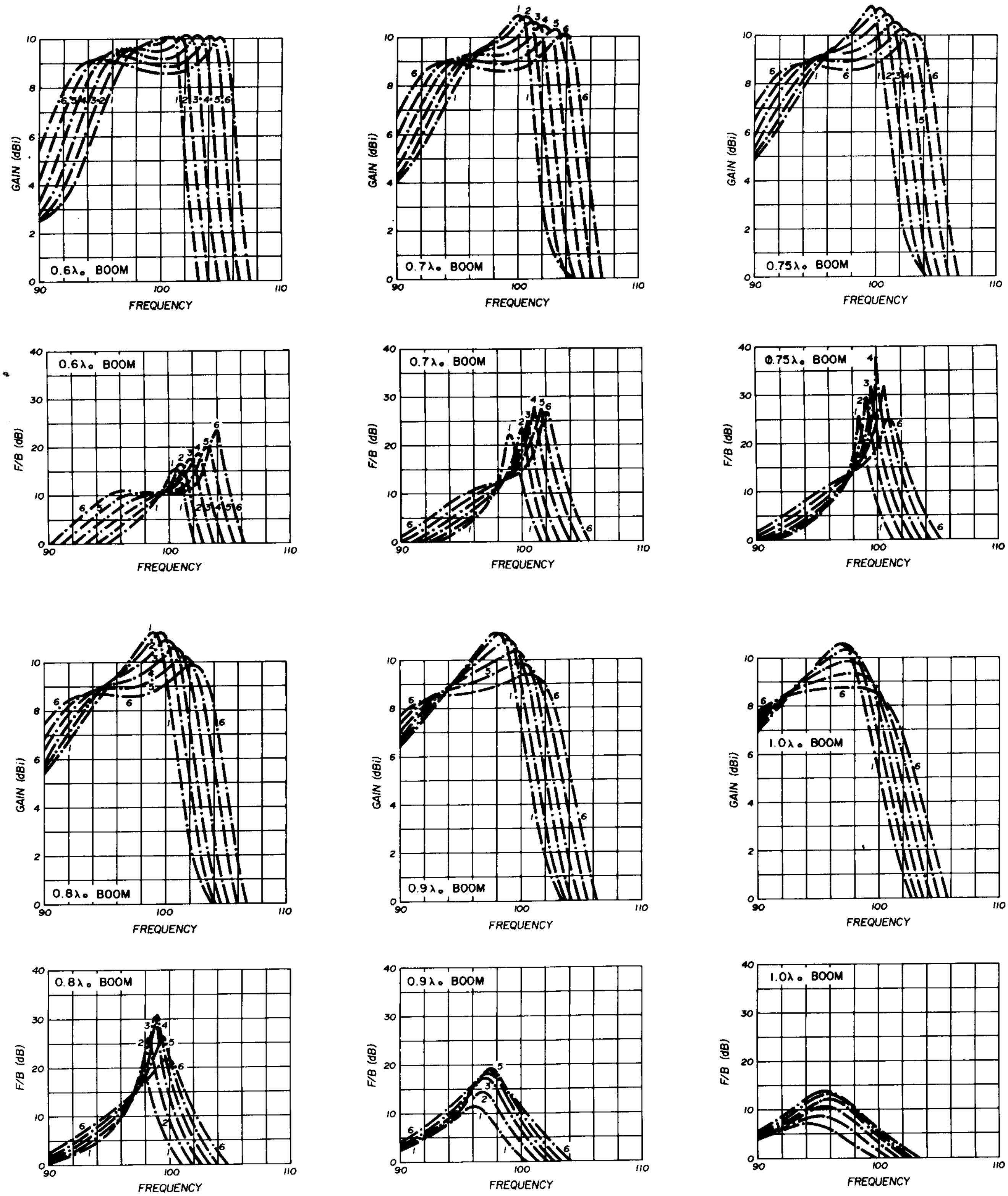


fig. 12. Gain and front-to-back (*F/B*) ratio for four-element Yagi beams with varying boom lengths, and changing reflector and director lengths (see table 3 for complete data). Boom lengths from $0.1\lambda_o$ to $0.5\lambda_o$. See next page for boom lengths from $0.6\lambda_o$ to $1.0\lambda_o$.

frequency separation of reflector and director; this observation will also prove to be generally true for all simplistic Yagi antennas! The bandwidth of the *F/B* performance (when the *F/B* is very high) is small; this is due to the critical nature of low back radiation.

Back radiation is very low only when there is vectorial cancellation of field in the back direction; this comes about only where element complex currents



Gain and front-to-back (F/B) ratio for four-element Yagi beams; boom lengths from $0.6\lambda_o$ to $1.0\lambda_o$.

are accidentally favorable for such cancellation. When this happens very small changes in those currents, e.g., by shifting frequency slightly, will destroy the favorable vectorial cancellation. This general result is inherent in all Yagi antennas; if the F/B is exceptionally high it will be so only over a very narrow frequency band!

Similar results for 4-element simplistic beams are shown in **fig. 12**; results for 5-, 6-, and 7-elements, although not plotted here, show increasing complexity with number of elements of the frequency-swept plots; this is caused primarily by the larger number of resonances in the system. The gain "cutoff" at high frequencies is also increasingly abrupt due no doubt to the large number of directors (which shift over to "reflectors" at high frequencies). F/B curves become very complex. Moreover, really high values of F/B (greater than 30 dB) are quite rare; it is very difficult to find combinations where vectorial cancellation in the rear direction is nearly complete!

summary

Simplistic Yagis with two, three, and four elements with boom lengths to 1.0λ have been systematically explored, and it has been shown that the gain function is generally not flat and the F/B ratio varies greatly from one example to another. Next month I will continue this discussion with a series of graphs which show gain and front-to-back ratio for 6-element Yagis with boom lengths up 1.5λ. I will also compare the performance characteristics of Yagis with up to seven elements and present interesting new data on the subject of front-to-back ratio.

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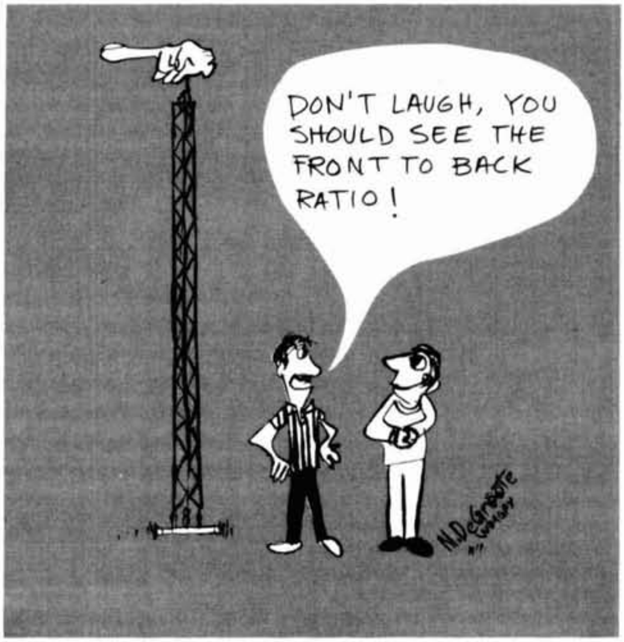

More Details? CHECK—OFF Page 94

notes on ground systems

How to provide an effective ground system for your station and how to measure ground-system resistance

The old timers took their ground systems very seriously. Quoting from *Practical Wireless Telegraphy* by Elmer E. Bucher, (1921):

> The earth plate is sometimes very elaborate and may consist of a great number of copper or zinc plates buried in moist ground to a depth of several feet.

Most ham stations don't have a proper ground, or, in many cases, none at all. The ground system must have very *low* resistance for good performance of receiver and transmitter and for reducing radio-frequency interference.

A good ground system makes as good a contact as possible with the earth. A large surface area, as well as depth to moist earth, is essential. Several ground rods of large-diameter copper (at least 5/8 inch or 16 mm) will meet these requirements if driven in 6 to 8 feet (1.8-2.5 meters).

In this article I discuss the delta-Y ground-rod configuration, which is efficient and far superior to a single ground rod, utility ground system, or water pipe. Also discussed is a straightforward method of measuring net resistance of the ground system.

system considerations

If desired, three rods may be used in a delta arrangement without too much increase in the net ground resistance. The delta or Y configuration isn't mandatory but does provide a convenient way of measuring the net ground resistance and thereby a means of determining the quality of the ground system.

An ac voltage is employed to measure the resistance to avoid dc electrochemical effects such as battery action and polarization. If available, an ac megohmmeter could be used to measure the resistance between the respective ground rods.

The ground rods should be copper or copper-clad steel and 6-8 feet (1.8-2.5 meters) long. Ground rods using 3/8-inch (9.5-mm) copper clad steel are generally available. Five-eighths inch (16-mm) copper tubing would be better but in some soils it may be very

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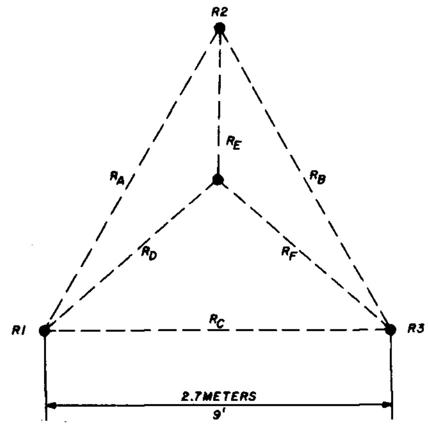

fig. 1. Delta configuration of ground rods for measuring the net resistance of the system to ground. Ground rods are designated R1, R2, and R3; R_A, R_B, R_C, R_D, R_E, and R_F are the ground resistances between the designated rods.

difficult to drive. Aluminum should be avoided, and galvanized steel is not very satisfactory.

Do not use the electric utility ground bus, as the common impedance will introduce the noise and interference on that ground wire. Water pipes are not very satisfactory for a variety of reasons.[1] Many times, if copper plumbing is used in the house, the copper pipe extends only about 10 feet (3 meters), and from there on plastic pipe is used. With galvanized pipe, the resistance of the coupling joints as well as the surface resistance may be quite high. The fact that the pipe is full of water does not contribute to its effectiveness as a ground.

The antenna tower or mast should not be connected to the station ground because of the hazard of lightning; furthermore, never ground the tower down through the concrete foundation; a lightning strike would probably shatter the concrete. All ground leads from the equipment to the ground bus should be as short as possible. One-half inch (12.5-mm) or wider copper braid, tinned at each end and drilled for strapping to the ground terminal, makes a satisfactory and flexible connection.

The connecting wires should be as large as possible: no. 10 or no. 8 (2.6 or 3.3 mm) copper to keep resistance and reactance as low as possible. Two wires in parallel are equivalent to three sizes larger; hence,

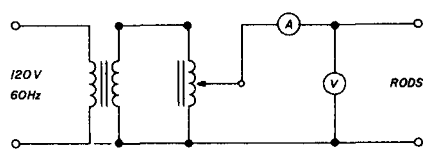

fig. 2. Test setup for measuring ground resistance. When the voltage is adjusted to provide 1 ampere of current, the value of the voltage is equal to the resistance in ohms.

two no. 10 (2.6 mm) wires would be equivalent to a single no. 7 (3.7 mm) wire. The dc resistance of no. 7 (3.7 mm) copper wire is 0.5 ohm per 1000 feet (305 meters), so for connecting lengths less than 10 feet (3 meters) the dc resistance would be about 0.005 ohm. Because of skin effect, the rf resistance will be higher; at 14 MHz it would be about 0.35 ohm.

Avoid connecting lengths that are a half wavelength or multiples thereof at the operating frequency, because they would act like a half-wavelength antenna. Also avoid quarter wavelengths, as they present a very high impedance at the resonant frequency.

Do not let a bare ground wire to the equipment touch any metal, as the intermittent contact will introduce serious noise.

resistance measurements

The following procedure may be used to determine the net resistance of the delta-Y configuration to

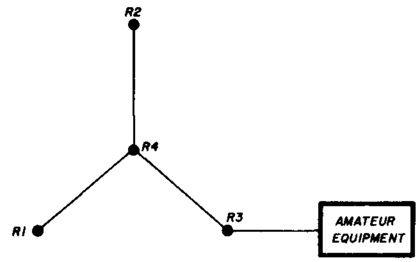

fig. 3. Proper method for connecting the ground rods together for the station ground.

ground (see **fig. 1**). In the following example, the delta sides are 9 feet (2.7 meters).

Using an isolation transformer, Variac, ac voltmeter, and ac ammeter as shown in **fig. 2**, determine the resistances between each pair of ground rods. Use the Variac to adjust the voltage until 1 ampere is obtained. Then the value of the voltage will be equal to the resistance in ohms. Determine R_A, R_B, R_C, R_D, R_E, and R_F in this manner.

Calculate R_1:

$$R_1 = \frac{1}{2}(R_A + R_C - R_B) \qquad (1)$$

which is one half of the sum of the two adjacent legs of the delta minus the opposite leg.

Likewise calculate:

$$R_2 = \frac{1}{2}(R_A + R_B - R_C) \qquad (2)$$

$$R_3 = \frac{1}{2}(R_B + R_C - R_A) \qquad (3)$$

$$R_4 = \frac{1}{2}(R_D + R_E - R_A) \qquad (4)$$

R_1, R_2, R_3, and R_4 should be essentially the same, and if so, the net resistance of the configuration to ground will be

$$R = \frac{R_1}{4} \tag{5}$$

If the values of R_1, R_2, R_3 and R_4 are significantly different, calculate the net resistance of the four in parallel. The value of the individual rod-resistance-to ground is about 10 to 20 ohms and depends on the type of soil, moisture content, depth, and rod size.

$$R_X = \frac{R_1 R_2}{R_1 + R_2} \quad R_Y = \frac{R_3 R_4}{R_3 + R_4} \quad R = \frac{R_X R_Y}{R_X + R_Y} \tag{6}$$

The net resistance of the connected rods should be less than 5 ohms. The rods are connected as shown in **fig. 3**.

calculating wire inductance

The self-inductance of a single wire may be calculated by the following formula (National Bureau of Standards Circular No. 74):

$$L = 0.002\, \ell\, (2.303 \log \frac{4\ell}{d} - 1)\ \mu H \tag{7}$$

Example:

$$\ell = 9\ feet\ (274\ cm)$$

$$d = no.\ 7\ AWG = 0.14\ inch\ (0.36\ cm)^2$$

$$L = 0.002 \times 274\ (2.303 \log \frac{4 \times 274}{0.36} - 1)$$

$$= 4\ \mu H$$

At 4 MHz, $X_L = 2\pi \cdot 4 \cdot 4 = 100\ ohms$

Contrast this with the reactance of a 25-foot (8-meter) length of no. 16 (1.3-mm) ground wire, which would be over 200 ohms. The length and size of the wire are the determining elements of the resulting inductance, so it's readily seen that the length must be as short as possible and the wire size as large as possible.

The procedure used in determining the ground resistance is covered on page 257 of the Government Printing Office publication *DCAC 330-175-1* addendum 1.

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ham radio

dual quad array
for two meters

Design and construction of a quad array that challenges a Yagi-Uda with the same number of elements

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Several months of work on two meters with quad antennas of various designs and configurations have resulted in an improved design using all-metal construction. The driven elements are of the closed-loop type,[1] employing an improved feed method that provides ease of adjustment and an excellent match to the feed system.

This construction method offers several advantages, both mechanical and electrical, over the usual insulated-spreader type of quad layout. The all-metal structure will withstand severe environmental conditions such as high wind or ice loading. It also presents a grounded system for electrical charges that may be induced by a severe electrical storm.

description

The dual quad array consists of two 4-element quads mounted on a common cross boom spaced approximately 5/8 wavelength apart. The quads are connected by 3/4-wavelength phasing sections of RG-59/U foam-filled coax. (More on this later.)

Basically, a quad antenna is a one-wavelength conductor that may take the form of a square, diamond, or round loop. Regardless of configuration, the quad antenna's electrical characteristics remain essentially the same. In this article I refer to it as a quad loop.

The two halfwave dipoles diagrammed in **fig. 1A** show the formation of a quad loop. They have two low-impedance points, so they may be mounted to a metal support without affecting their electrical characteristics. The voltage curve along a halfwave dipole shows maximum voltage at the ends, with the center at zero potential (low impedance), this being points **A** and **B** of the dipoles.

If the dipoles are spaced 1/4 wavelength apart and their ends folded over at the 1/8-wavelength points and joined together, a cubical quad is formed (**fig.**

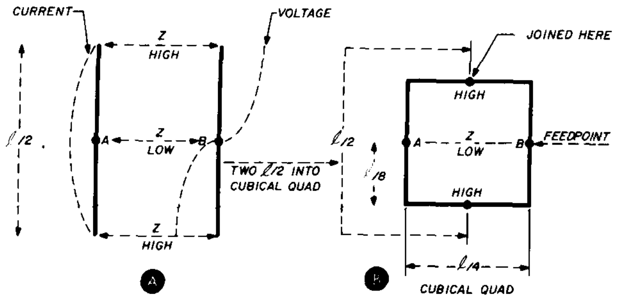

fig. 1. Principles of a quad antenna. Two halfwave dipoles form a quad loop, (A). A cubical quad is formed by folding the ends at the 1/8-wavelength points, (B). Mounting points A and B are at zero rf potential. Polarization depends upon feedpoint: vertical when fed from side, horizontal when fed at top or bottom.

1B). Points **A** and **B** remain at zero rf potential so long as the feedpoint is at either **A** or **B**.

feedpoint considerations

The feedpoint to a quad loop determines the voltage and current distribution around the loop as well as the polarization of the emittted wave front.

The quad loop looks and performs like two half-wave dipoles connected back-to-back. If the quad loop is fed at either side, maximum current flow occurs in the vertical sides; hence it's vertically polarized. If fed at either the top or bottom, the voltage and current nodes are shifted around the loop by 90 degrees and the quad becomes horizontally polarized.

loop configuration

Circular loops are used in the dual quad array described here. They are easily formed and perform slightly better than the other configurations at the higher frequencies. (High-frequency currents don't like sharp bends or abrupt changes, and the circular configuration offers a more uniform transition from the low-to-high impedance points around the loop.)

The circumference of the driven loops can be determined by a simple equation. Circumference of the loop is:

$$C = \frac{12,060}{f\,(MHz)} \qquad \textbf{(1)}$$

where C is the loop circumference in inches. For centimeters, the numerator in **eq. 1** is replaced by *30.624*. The driven loops were cut to 82 inches (208 cm), which is near the center of the 2-meter band. The reflector is 2 inches (51 mm) longer, and the directors progressively 2 inches (51 mm) shorter. Spacing is 16 inches (406 mm) on the reflector and 12 inches (305 mm) on the directors.

matching system

Common practice is to open the loop at the desired feedpoint and attach a 50-ohm feedline. This practice gives an acceptable match, but it has been found that a more desirable method is to leave the loop closed and feed it with a modified gamma match as shown in **fig. 2.** This method makes for an easy adjustment of SWR and gives an excellent match to the phasing harness. The gamma rods are 8 inch (203 mm) lengths of 1/4-inch (6.5-mm) copper tubing. The gamma capacitor is a miniature Johnson variable. A cap with 15-20 pF maximum capacitance is sufficient. The capacitor is mounted in a plastic tube and sealed for weather protection. [I used 1 inch (22.5 mm) diameter plastic pill boxes in the original *construction.*]

construction

Construction of the array is quite simple. Hand tools will be adequate for the job. Most of the materials are off-the-shelf items obtainable in any hardware store.

The main framework (**fig. 3**) is constructed of thin-wall 1/2-inch (12.5-mm) electrical conduit. Pipe straps, as used for mounting 1/2-inch (12.5-mm) tubing, are used throughout the assembly for mounting the loops and securing the 1/2-inch (12.5-mm) conduit to the mounting points.

The loops (**fig. 4**) are constructed of no. 8 (3.3-mm) aluminum wire sold as TV ground wire. Two strands of this wire are used in each loop. The strands are tightly twisted together to form a semi-rigid conductor.

1. Clamp the two ends of the wire in a bench vise and chuck the other ends into an electric drill motor. Keep the wires evenly spaced by applying a little pressure.

2. Turn on the drill motor and the wires will be tightly and evenly twisted together.

3. Cut the wires about 6 inches (152-mm) longer

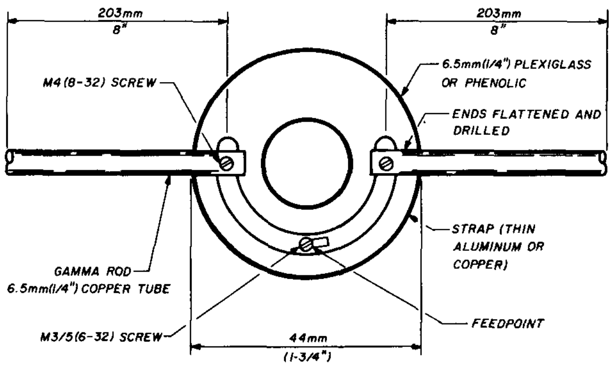

fig. 2. Matching system used in the dual quad antenna. A modified gamma match makes for easy SWR adjustment and gives an excellent match for the phasing harness.

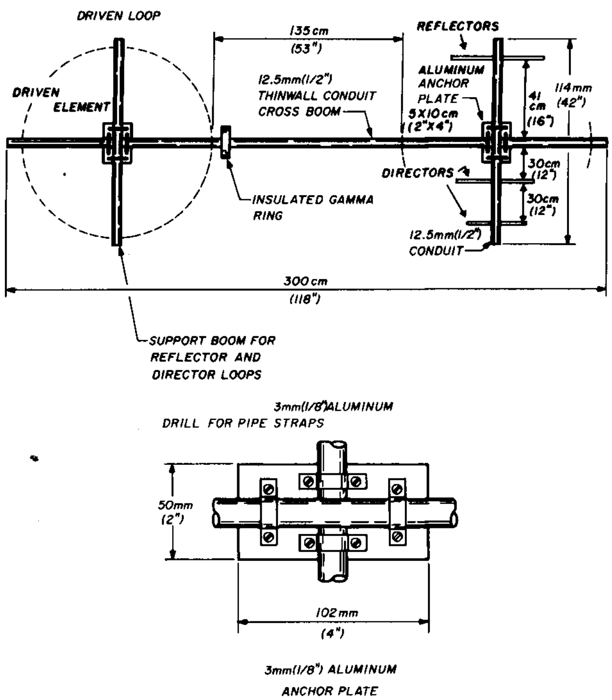

fig. 3. Construction of the main framework of the dual 2-meter quad.

than the desired loop, as they will be shortened by the twisting action.

4. Hand form them into a loop that will be rigid when mounted to a metal cross member.

The insulated mounting rings to which the gamma rods are attached are cut from 1/4-inch (6.5-mm) plexiglass or phenolic. Use a 1 × 3/4 inch (25.4 × 19 mm) hole saw.

1. Drill the centers to slip over the 1/2-inch (12.5-mm) conduit cross member.

2. Flatten the copper tubing gamma rod ends in a bench vise and drill for mounting to the insulating rings. A half-circle strap connects the ends of the gamma rods together; this may be made of copper or thin aluminum.

3. Drill the center of the strap for a 6-32 (M3/5) screw, which secures a solder lug at this point.

This solder lug is the feedpoint and connects to the inner conductor of the phasing harness. The coax braid is being attached directly to the cross boom and secured by another screw and solder lug.

phasing harness

The phasing consists of two equal lengths of RG-59/U coax cut to an electrical 3/4 wavelength and terminated in the center to an SO-239 connector to which the main 50-ohm feedline connects. Because of the coax velocity factor, the actual length will be shortened by this factor. Unfortunately, the propagation velocity will vary between cables of different coax brands.

Foam-filled cable comes out to be near 47 inches (119 cm) for 3/4 wavelength at 2 meters, while the solid type comes out near 36 inches (91 cm).

The recommended method of determining the electrical length is to cut a length of cable slightly longer than the estimated length required. Short one end with a small pickup loop and couple this loop to a grid-dip oscillator. Carefully trim off the free end until you get a dip near the center of the 2-meter band.

tuneup

Each quad section is tuned separately.

1. Connect a 50-ohm feedline from the transmitter to the solder lug feedpoint. (The coax shield is grounded directly to the cross boom.)

2. Set the shorting strap that connects the lower gamma rod to the radiator four inches (102 mm) below the feed point. This dimension may be adjusted if unity SWR is not obtained by adjusting the gamma capacitor.

3. Insert an SWR meter into the line, preferably near the antenna where it may be easily observed.

4. Apply power to antenna at a frequency near the

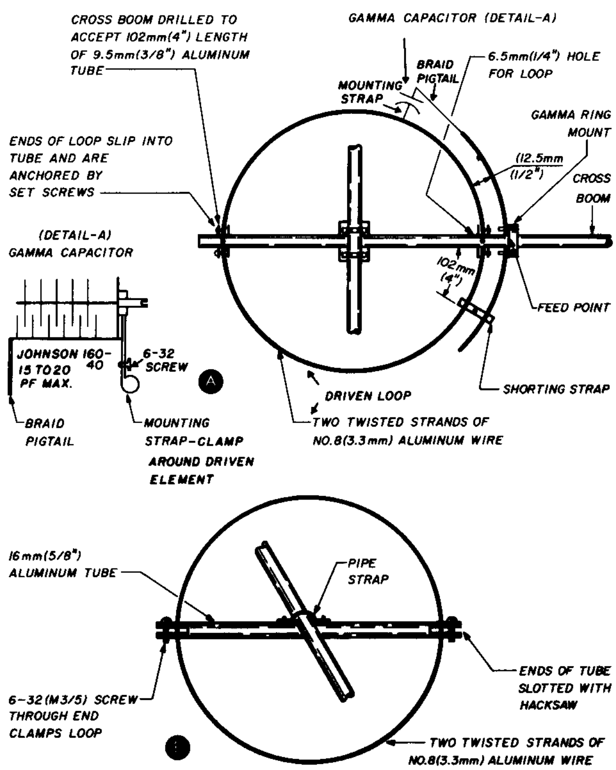

fig. 4. Construction of the driven loop and gamma-match capacitor (A). Sketch (B) shows reflector and director mounting details.

center of the 2-meter band. Use reduced power to prevent interference.

5. Note meter reading. With an insulated tool, adjust the gamma capacitor until a reading of near unity SWR is obtained. Use the same procedure for the other quad.

6. Now connect the phasing harness and main feedline. A slight adjustment of the gamma capacitor will again bring the SWR reading to near unity.

You must, of course, observe the usual precautions of having the antenna in the clear while making these adjustments. Height above ground doesn't affect the quad as much as the Yagi for tuneup adjustments. You are now ready for on-the-air tests with that distant station you've been unable to work.

in retrospect

Those familiar with the Swiss quad have no doubt noted that it's also an all-metal design, with closed loops and a modified gamma match.[2] The Swiss quad has been popular in Europe for several years and is now making an appearance in this country. It's a very good antenna, but I must add that the dual quad array shown here has out-performed it at my location.

Over the years, there's been much controversy concerning the relative merits of the quad versus the Yagi.[3] My only comment is this: Compare this dual quad array with your favorite Yagi, with a comparable number of elements, using on-the-air tests with a distant station. I think you'll find that on-the-air tests don't always agree with gain measurements made on an antenna range under controlled conditions.

This quad array has a low takeoff angle of radiation and will work quite well at low heights above ground. It's very tolerant of variations in dimensions and very easy to match. Directivity is very sharp; a variation of a few degrees can mean the difference between an S1 and an S9 signal. If you wish to use the array for horizontal polarization, rotate the array 90 degrees so that the quads are stacked one above the other.

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3. Wayne Overbeck, N6NB, "Quads vs Yagis Revisited," *ham radio*, May, 1978, pages 12-21. Also *Comments, ham radio*, October, 1979, page 80.

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ham radio

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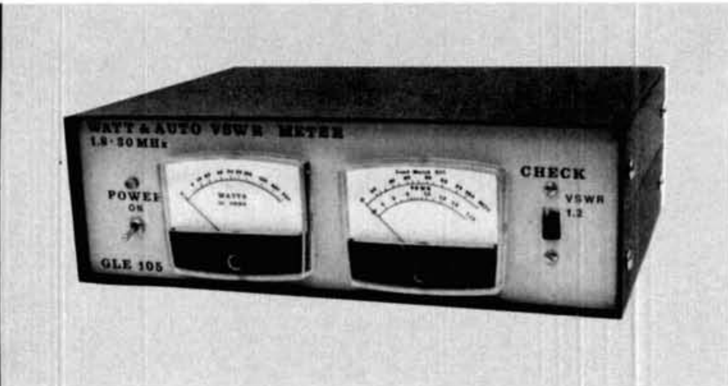

automatic VSWR and power meter

Design and construction of an instrument that indicates rf power and VSWR simultaneously

One of the most common station accessories used by the Amateur Radio operator is the VSWR meter, which determines the voltage standing wave ratio between transmitter and antenna. VSWR is a measure of the quality of the system match, or may be looked at as a measure of system efficiency. Many articles have been written stating that a high VSWR doesn't usually seriously degrade transmission-line performance. Also the articles have correctly stated that reduction in radiation efficiency caused by antenna nonresonance is barely noticeable.

Now that most Amateurs are convinced that their 80-meter dipole will work from 3.5-4 MHz even though the VSWR may be high at either end, they're faced with the VSWR limitation of their transceiver. To solve this problem, a transmatch or antenna tuner is placed between transmission line and transmitter.

In light of the previous comments, it's not as important to use a VSWR meter to monitor the transmission line VSWR as it is to monitor the VSWR between transmitter and antenna tuner.

The antenna tuner introduces more knobs to be adjusted during tune up and can cause some delay in tune up because of interaction between loading adjustments. Also, because of the moderate *Q* involved in the tuner, you can easily encounter VSWRs from infinity to 1:1 while adjusting the tuner. Thus, it's usually desirable to do initial tuning at low power and final tuning at full power. The wide range of power and VSWR encountered during tuner operation makes use of the conventional VSWR meter difficult, because the REF or CAL point changes, which causes inaccurate VSWR readings. This is where an automatic meter can greatly speed up the tuning procedure, because the VSWR-meter readings are accurate and independent of power level down to some minimum power level.

automatic VSWR meter

The automatic VSWR meter described in this article is unique, versatile, and easy to use. The basic circuit design is covered by U.S. Patent 4,110,685. It's battery operated and has an automatic ON/OFF feature for extended battery life. Two meters that display power and VSWR simultaneously give a greater feel for how well the transmitter is operating on a continuous monitoring basis. Also, the two-meter display of power and VSWR as independent

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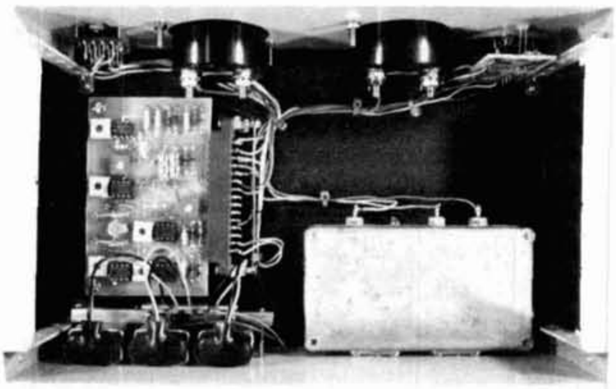


Inside view — complete instrument.

parameters greatly speeds up antenna loading adjustments and gives greater confidence that the transmitter is operating properly without any switching, reference setting, or mental calculations.

how it works

As in all VSWR meters (**fig. 1**), an in-line directional coupler senses and develops a voltage proportional to the forward and reflected voltage on the transmission line. The directional coupler in this instrument also has a diode compensation network to provide additional linear range at low levels. It also senses when rf is present to saturate a transistor, which is used to turn the instrument on.

The signal from the directional coupler that senses rf power is fed to a circuit that uses transistors to turn the supply voltages of +16 and −9 volts to the analog computing circuits ON or OFF.

The directional-coupler dc outputs are connected to fet input buffer amplifiers to provide a high-impedance load to the directional coupler outputs and low impedance outputs for the logarithmic amplifier and wattmeter.

Dc outputs V_F and V_R are linearized to provide outputs that can be used directly. Thus V_F can be used to drive a wattmeter. Power is displayed in watts on a scale constructed by using the formula

$$P = \frac{V_F^2}{R} \tag{1}$$

Since dc output voltages V_F and V_R are developed by peak-detecting diodes, the wattmeter scale displays two decades of power range; *i.e.*, the 250-watt full-scale meter displays power from 2-250 watts. This can be seen in the photo of the meters. A peak detector whose output is calibrated to read volts rms or power can have errors if the signal has large harmonic content. However, in the rf transmitter applications such as this, the signal usually has a very low harmonic content; thus the peak detector gives accurate results.

The logarithmic amplifier develops a voltage at the output with a relationship proportional to the logarithm of the input voltage. At the log amp outputs are two voltages that are the logarithm of V_F and V_R. An expression called return loss, which is used by the telecommunications and instrument industry, is defined as follows:

$$\begin{aligned} \text{return loss} &= 20 \log 1/\rho \\ &= 20 \log V_F/V_R \end{aligned} \tag{2}$$

where ρ = reflection coefficient

By mathematical equality, **eq. 2** can also be expressed as

$$\text{return loss} = 20\,(\log V_F - \log V_R) \tag{3}$$

It can now be seen that if we take the difference of the two voltages, log V_F and log V_R, the result will be a voltage proportional to the return loss in dB:

$$E_{RL} = \log V_F - \log V_R \tag{4}$$

Return loss is related to VSWR by

$$RL_{dB} = 20 \log (VSWR + 1)/(VSWR - 1) \tag{5}$$

By scaling construction the meter can be made to display VSWR (see the VSWR-meter photo). Voltage E_{RL} is the difference between voltages log V_F and log V_R, which is always present from the log amps. Thus VSWR is automatically and continuously displayed with no need to set a reference and operate a switch.

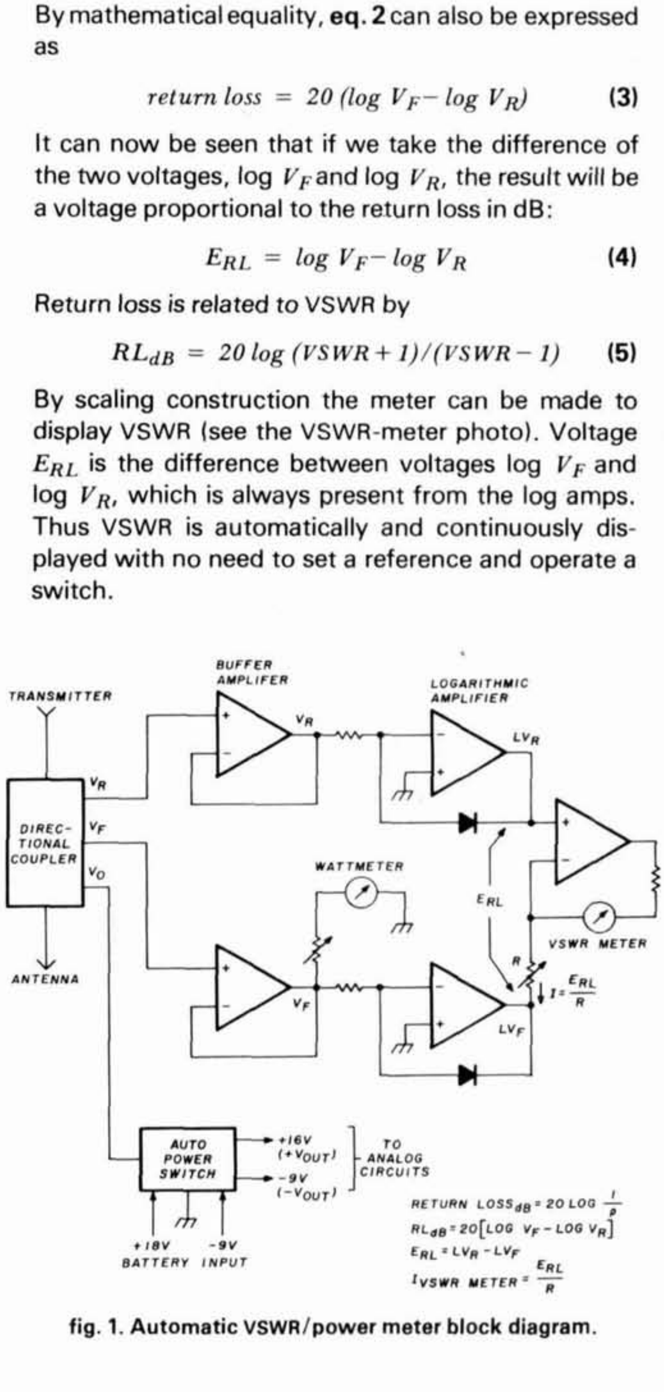


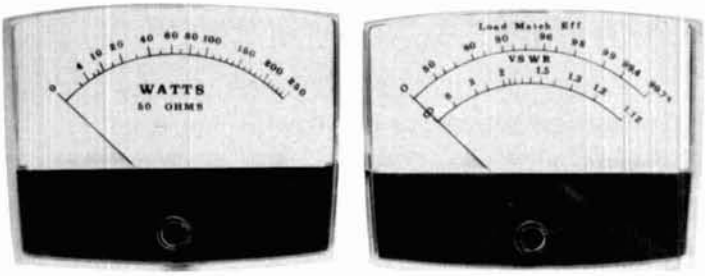
fig. 1. Automatic VSWR/power meter block diagram.

VSWR-meter scale

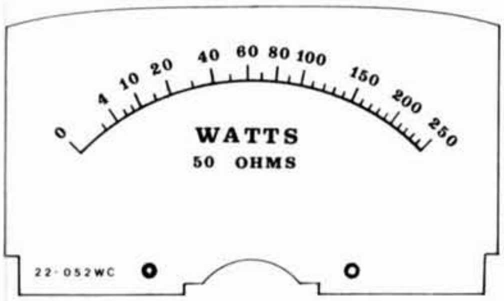
One of the things you'll notice when you look at the VSWR meter scale (photo) is that it's "backwards." With this meter you peak the VSWR meter as well as the wattmeter for best loading.

Having $VSWR = \infty$ at the left-hand end of the meter is explained by the way VSWR is computed. Note **table 1**, in which the three parameters, reflection coefficient, VSWR, and return loss, are tabulated.

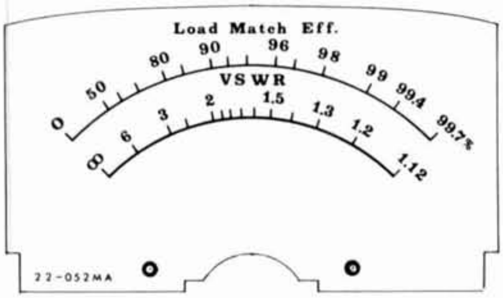
From this table you can see that when $VSWR = \infty$, return loss = 0 dB; and conversely, when $VSWR = 1$, *return loss* $= \infty$ *dB*. In this instrument return loss is computed so the display of $VSWR = \infty$ is no problem, because the subtraction of two equal voltages is easily made electronically. However,



Wattmeter and VSWR meter scales.



Wattmeter scale — actual size.



VSWR scale — actual size.

table 1. Reflection coefficient, ρ, VSWR, and return loss.

ρ	VSWR	return loss (dB)
1.000	∞	0
1.891	17.391	1
1.794	8.724	2
1.708	5.848	3
1.501	3.010	6
1.398	2.323	8
1.316	1.925	10
1.200	1.499	14
1.126	1.288	18
1.100	1.222	20
1.063	1.135	24
1.056	1.119	25
1.032	1.065	30
1.010	1.020	40
1.003	1.006	50
1.001	1.002	60
1.000	1.000	∞

there's a problem in the display of $VSWR = 1$, because this value is equal to infinite return loss. Obviously, a display of zero to infinite return loss in dB is impossible. As a result, a practical limit must be selected, so I've chosen to limit return loss to 25 dB, or a VSWR of 1.12.

This limit was chosen for practicality. A VSWR of 1.12 represents an efficiency of 99.7 per cent of the available power being delivered to the load. Ivory Soap long ago convinced the consumer that 99.44 per cent pure soap was good enough, and I feel that 99.7 per cent of my transmitter power delivered to my antenna is good enough.

With the VSWR scale is a scale called LOAD EFFICIENCY in per cent. This scale greatly enhances your feel for system efficiency. (There's always the question, Just what does VSWR mean and how much should I have?) The scale is also a constant reminder that there's a reasonable limit to how *low* you must keep the VSWR. Another practical reason for the limit in the displayed VSWR is that a directional coupler with isolation good enough to measure low VSWR numbers of high return-loss numbers is difficult to construct.

directional coupler

The directional coupler is of conventional design and works on the principle described by Bruene;[1] however the design of this directional coupler for specific applications wasn't covered. I've developed some simple formulas that can be used in predicting, to a good approximation, the values needed to obtain the desired operation. Reference 1 covers the theory of operation and some considerations for the directional coupler design. I urge you to review this fine article. The basic circuit is shown in **fig. 2** and is used to develop the formulas.

Bridge balance. The basic principles of the directional coupler is that, at bridge balance, the voltage presented to reflected diode detector CR_R is zero and the voltage presented to forward diode detector CR_F is E_D. The diode-detector voltage output is determined by two voltages proportional to the magnitude and phase of transmission-line voltage E_V and current I_i. The voltage proportional to transmission line current I_i is made to appear in phase with I_i on the reflected diode detector by the center-tapped resistor load for the current-to-voltage transformer.

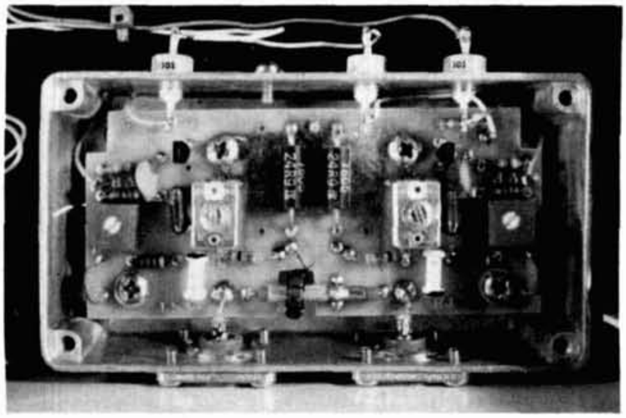
At bridge balance, and with a reference resistive load, $E_O = E_D/2$ is in phase on the reflected side and -180 degrees out of phase on the forward side. With these conditions the forward diode detector voltage is $E_O + E_D/2 = E_D$, and the reflected diode detector voltage is $E_O - E_D/2 = 0$.

When a load other than the resistive reference value is present, the bridge will not be balanced, and the voltages presented to the diode detectors will be determined by both magnitude and phase of the voltages E_O and $E_D/2$. The amount of unbalance is detected in the diode detectors. Their dc outputs result in the outputs, voltage forward V_F and voltage reflected V_R, from which the ratio of these two voltages determines the VSWR.

There's no unique solution that will completely design the coupler. **Table 2** lists the main parameters and guidelines to design this type of directional coupler. From the previous paragraph note that, at bridge balance, $E_O = E_D/2$ and also that the voltage presented to the diode is E_D. Since voltage E_D across

table 2. Design guidelines.

parameter	minimum	maximum
diode voltage	diode threshold voltage	diode breakdown voltage
insertion resistance	none	power in resistor and design maximum
value of $C1$ for loading transmission line	none	$X_{C1} \geq 10 \cdot Z_O$ at highest frequency of interest
number of turns on toroid core	$X_L \geq 5 \cdot R$ at lowest frequency of interest	length of wire $\leq 1/20\lambda$ at highest frequency of interest
value of $C2$	$C2 \geq 25 \cdot C_D$; C_D = diode capacitance	



Inside view — directional coupler.

the diode is a parameter to keep track of, I've found it convenient to develop my formula using E_D.

Current transformer. Now for the expression to use for the current transformer. Assume the conditions for a valid transformer are met. Then $E_D = E_i \cdot N$, since the primary in this case has only one turn. Also $E_i = R_I I_i$; $I_i = \sqrt{P/R_L}$; and $R = R_I N^2$. Putting all this together, the expression to work with for design is

$$E_D = \frac{R}{N} \sqrt{P/R_L} \tag{6}$$

From this expression we see that, at a given power level, E_D is increased with increasing values of R and decreased with increasing number of turns.

For the above expression to be true, current-transformer action is assumed. To obtain this, the inductive reactance of the transformer secondary must be $\geq 5 \cdot R$ at the lowest frequency of interest.

To compute the inductance of a toroid inductor, the expression $L = N^2\, LT/NT^2$ is used. LT/NT is the A_L or *inductance index* of the toroid. If A_L is expressed in inductance per unit turn, the inductance of a toroid is the number of turns squared times A_L or $L = N^2 A_L$. After calculating the toroid inductance, the reactance at the lowest frequency of interest can be determined by

$$X_L = 2\pi f L \tag{7}$$

As for E_D, the value of R and N also determines the directional coupler insertion resistance. Insertion resistance is equal to R divided by N^2; $R_I = R/N^2$. Insertion loss can also be expressed in dB for a 50-ohm system:

$$dB_I = 20 \log \frac{100 + R_I}{100} \tag{8}$$

The current transformer load, R, will have power applied during operation, and the power in R can be calculated by

$$P_R = E_D^2/R \tag{9}$$

The voltage at the other side of the diode is determined by capacitive divider $C1$ and $C2$. Voltage-divider output E_O is equal to E_v times $C1$ divided by $(C1 + C2)$. If we let $E_v = \sqrt{P \cdot R_L}$ and $E_O = E_D/2 = \frac{R}{2N}\sqrt{P/R_L}$ (condition for bridge balance) and solve for $C2$, we obtain

$$C2 = \left[C1 \quad \frac{2R_LN}{R} - 1\right] \tag{10}$$

This expression is convenient because it's in terms of the two parameters usually adjusted to obtain the desired performance.

In summary, here are the expressions needed to solve for the values of the components for a directional coupler:

$$N = \frac{R}{E_D}\sqrt{P/R_L}\ (turns)$$

$$L = N^2 \cdot A_L\ (A_L \text{ is inductance per unit turn})$$

$$R_I = R/N^2\ (ohms)$$

$$P_R = E_D^2/R\ (watts)$$

$$C2 = C1\left[\frac{2R_LN}{R} - 1\right]$$

Design example. To gain a feel for using the formulas, let's work out the values used for the directional coupler in this article. (See the basic circuit, **fig. 2**). In this case I'm operating the diodes in a peak-detecting mode, so I'll select the diode voltage to be 10 volts rms when the maximum power of 250 watts is applied through the directional coupler. Also I'll select R to be 50 ohms and the frequency range to be 1.8-30 MHz. These initial design parameters will allow the component values to be calculated.

The number of turns, N, for the toroid is

$$N = \frac{R}{E_D}\sqrt{P/R_L}$$

$$= \frac{50\ ohms}{10\ volts}\ \frac{\sqrt{250\ watts}}{50\ ohms} = 11.18\ turns$$

Since we can't wind fractional A_L turns, the number of turns are rounded off to 11, which will be used in the following calculation.

Now we check to see if the number of turns is okay for inductance. Calculate $L = N^2A_L$ where $A_L = 2.1\mu H$ per turn for the Ferroxcube toroid core number 266T125 (**fig. 3**) and we find $L = 11^2 \cdot 2.1 = 254\mu H$. At 1.8 MHz, the inductive reactance is 2872 ohms. The inductive reactance is easily greater than 5 times 50 ohms, which is okay. Empirically, by winding the toroid core, we find the length of wire to be 18 cm. The maximum length of wire is approximately

$1 = \frac{300}{20f}$ in meters or $1 = \frac{1500}{f}$ in centimeters.

In this case, $1\ max = \frac{1500}{30} = 50\ cm$, which means my 18-cm length of wire is okay.

The insertion resistance is $R_I = R/N^2 = \frac{50}{112} = 0.4\ ohm$, and the power in the resistors at full scale is

$P_R = E_O2/R = \frac{102}{50} = 2\ watts$, or 1 watt per resistor. The values obtained are acceptable. A 25-ohm, 1-watt resistor is a practical value, and an insertion resistance of 0.4 ohm, which translates to a 0.04-dB loss, is reasonable. If, during this step, the power in the resistor is too high or insertion loss is unacceptable, you'd adjust either R or N or both and try again until an acceptable answer is obtained.

Capacitor values are determined by first selecting the value of $C1$, which should have an impedance of approximately $10 \cdot Z_O$ or 500 ohms at 30 MHz. The maximum value of capacitance is 10 pF. Since there are two $C1$s, each $C1$ has a maximum value of 5 pF. To obtain some margin, I've selected 3.3 pF for $C1$. From this selection of $C1$, $C2$ can be calculated by:

$$C2 = C1\left[\frac{2R_LN}{R} - 1\right]$$

$$= 3.3\,[22 - 1] = 69\,pF$$

The diode capacitance is about 2 pF maximum; therefore $C2$ should be greater than $2 \cdot 25$ or 50 pF. We must adjust the bridge so that $E_O = E_D/2$ for balance, so either $C1$ or $C2$ is made adjustable.

In summary, we find that for a 250-watt, 1.8-30 MHz directional coupler, the following values will work: $R/2 = 25\ ohms$; 11 turns on the toroid core; $C1 = 3.3\ pF$, and $C2 = 69\ pF$. I've verified that the preceding values will give the desired performance. The calculated values are ideal, and in practice the results will be slightly different. However, I've found from building a number of different types of directional couplers that the calculated and measured values are always quite close in agreement.

Dc output voltages V_F and V_R are taken from the junction of $C1$ and $C2$ (**fig. 2**). The resistor value or impedance must be high enough not to load $C2$, which means the load impedance should be approxi-

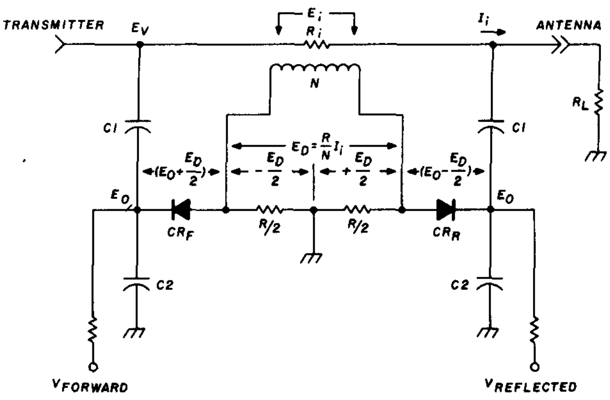


fig. 2. Directional coupler basic circuit.

Construction. The construction can be noted in the photo of the inside of the directional coupler. The mately 20 times or greater than $C2$ reactance at the lowest frequency of interest.

In this directional coupler design a diode compensation network uses the base-emitter junction of a transistor to extend the low-end range of the diode detector. Note the circuit in **fig. 3**. The compensation works by the variable attenuator formed by $R4$, $R2$, and $Q1$. When the dc voltage from the diode detector is high, the current in R2 is high, thus causing Q1 base-emitter junction to conduct and look like a low-impedance for R2 to ground. Since R2 is grounded, the detector voltage is attentuated by the ratio of R4 to R2. When the dc voltage from the diode detector is low, the current in $R2$ is low, causing $Q1$ base-emitter junction impedance to increase due to less current in $R4$, which, in turn, decreases detector-voltage attenuation to the V_F output. Note also that $Q1$, which compensates for V_F, has its collector brought out so that, when enough signal is present, $Q1$ collector saturates and turns on the power to the instrument through the ON/OFF circuit.

Calibration. The composition circuit is calibrated by applying a known 3 volts rms at some midrange frequency, say 7 MHz, and adjusting $R4$ ($R11$) for an output of 3 volts dc at V_F (V_R) with a 10-megohm voltmeter. Disconnect the anode of $CR1$ ($CR2$) from $R6$ ($R9$) and $L1$ for this adjustment. Calibration of the bridge for balance is straightforward. Adjust $C7$ for minimum voltage at V_R when connected in the normal manner. Reverse transmitter and load for adjusting $C4$ for minimum voltage at V_F. The use of a known good 50-ohm load is a must for proper calibration.

Because it's not easy to determine the sense of the toroid output, it may be necessary to reverse connection to the toroid to get voltages V_F and V_R at the proper side. I usually find a small amount of interaction in adjustments, so I repeat the procedure to be sure the directional coupler is calibrated accurately. directional coupler was constructed in a die-cast aluminum box, Bud no. CU-124. Feedthrough capacitors were used to bring out the dc signal voltages. The layout of the PC board isn't especially critical; however, a compact symmetrical pattern usually works best.

power on-off circuit

Power for the automatic VSWR meter comes from three standard 9-volt batteries. Two are connected in series to provide +18 volts and the other provides −9 volts to the analog circuits. The circuit is in **fig. 4**. When $R3$ is grounded by the saturated collector of $Q1$ in the directional coupler, the Darlington transistor pair $Q1$, $Q2$ is turned on so that the +18 volts is supplied to the analog circuits through $CR1$, which is a power-on indicator LED (amber).

When the positive supply goes on, current flows through $R4$, which turns on $Q3$, which in turn turns on $Q4$. This connects the −9 volt battery to the analog circuits. The ON/OFF switch is connected so that when it's in the open or OFF position, the instrument will not come ON even though rf power may be present in the directional coupler. The purpose for this is to allow for longer battery life because it's usually not necessary to monitor power and VSWR

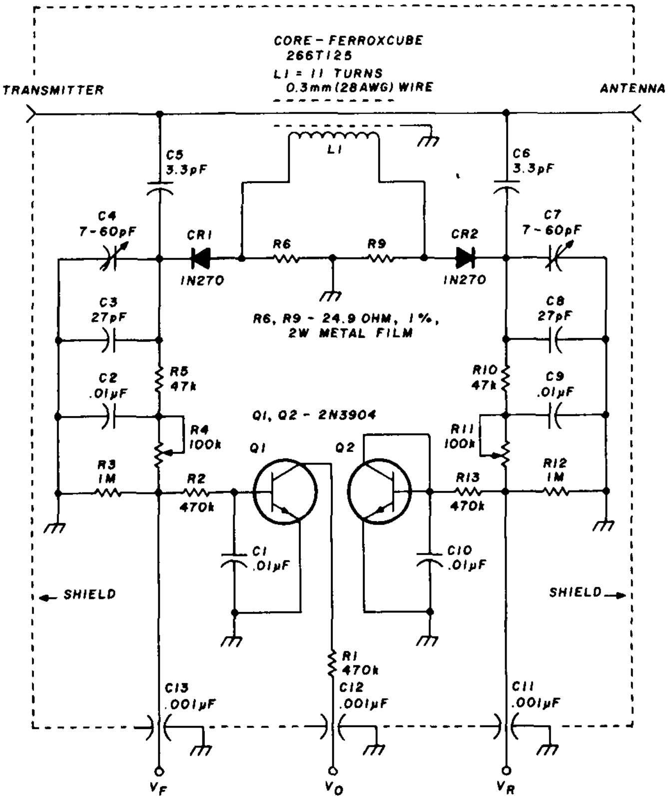
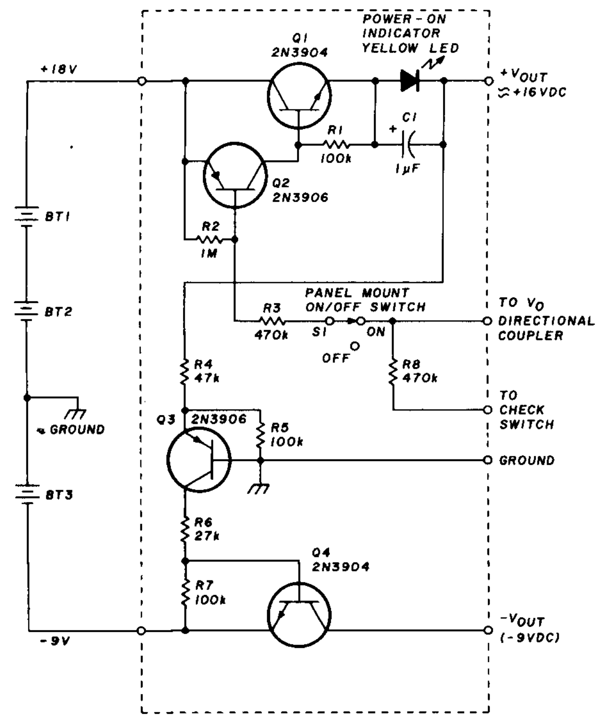


fig. 3. Directional coupler schematic.



BT1,2,3 STANDARD 9V BATTERY NEDA 1604
RESISTORS 1/4 WATT 5% CARBON COMPOSITION

fig. 4. Automatic power switch schematic.

after tune up and may also be distracting to see meters going up and down during normal CW or phone operation.

Expected battery life is about thirty-six hours for continuous operation. However, with the OFF switch and normal transmit-receive duty cycle, the expected life should be at least a year for the average Amateur. Battery operation is very desirable for ease of installation and use of the VSWR meter, especially for tuning mobile antennas.

A connection from the power ON/OFF circuit also goes to the CHECK switch, which turns on the power so that analog circuit calibration can be checked from time to time and also allows a measure of battery condition from the wattmeter. (This will be covered in more detail in the description of the check-switch circuit.)

analog circuits

The analog circuits (**fig. 5**) receive the dc signals from the directional coupler and, when power is applied, process the dc signals to be applied to the wattmeter and VSWR meter. The two dc signals from the directional coupler, V_F and V_R, are sent to the buffer amplifiers, which are connected in a unity-gain configuration. The output of the V_F buffer amplifier *U2* is connected to the input of V_F logarithm amplifier *U5* and also the wattmeter. The output of the V_R buffer amplifier, *U1*, is connected to the input of the V_R logarithmic amplifier, *U3*. Logarithmic amplifiers *U3* and *U5* are of a basic configuration using a grounded-base transistor for the feedback diode. Note in the circuit that the feedback diodes, *U4* are a matched transistor pair (National Semiconductors LM394BH).

In this application it's very important that the temperature and logging characteristics match, so that the difference in voltage between the two logarithmic amplifiers doesn't vary as a function of temperature and other environmental factors. The absolute voltage of each logarithmic amplifier will change, but that's not an important factor because the meter amplifier, *U6*, is connected to reject the common-mode voltage from the logarithmic amplifiers; thus only their voltage difference is measured. Also note in the diagram that diodes *CR1* and *CR2* are connected to prevent possible reverse voltage on the base-emitter junctions of *U4* from becoming too large.

The output voltages of the logarithmic amplifiers are called LV_F and LV_R; their voltage difference results in a new voltage, E_{RL}, which is proportional to return loss in dB. Meter amplifier *U6* is connected as a difference-voltage amplifier. The VSWR meter is connected in series with feedback resistors *R17* and *R18*. In this configuration, the current in the meter is determined by the value of $R15 + R14$ and E_{RL}. *R15* is adjustable, so that the scale factor, or calibration, of the VSWR meter can be set.

Diode *CR3* in the feedback circuit of *U6* limits the forward and reverse current through the meter to protect the meter from damage when VSWRs greater than 1.12 are measured. The reverse-voltage protection is necessary during initial calibration of the unit when a reverse polarity signal can easily be present.

Also note that the inputs to the meter amplifier are not referenced to ground, thus providing common-mode voltage rejection. The operational-amplifier inputs will never be more than plus or minus one diode drop from ground.

The analog board is an analog computer that computes return loss and, by scale construction on the meter, displays VSWR. Because most all operational amplifiers have offset currents and voltages, each operational amplifier has an offset voltage adjustment so that these errors can be compensated for proper operation. A voltage divider network consisting of *R19*, *R20*, and *R21* provides an accurate voltage ratio for calibration and check.

check-switch function

The check switch serves a very useful function. It

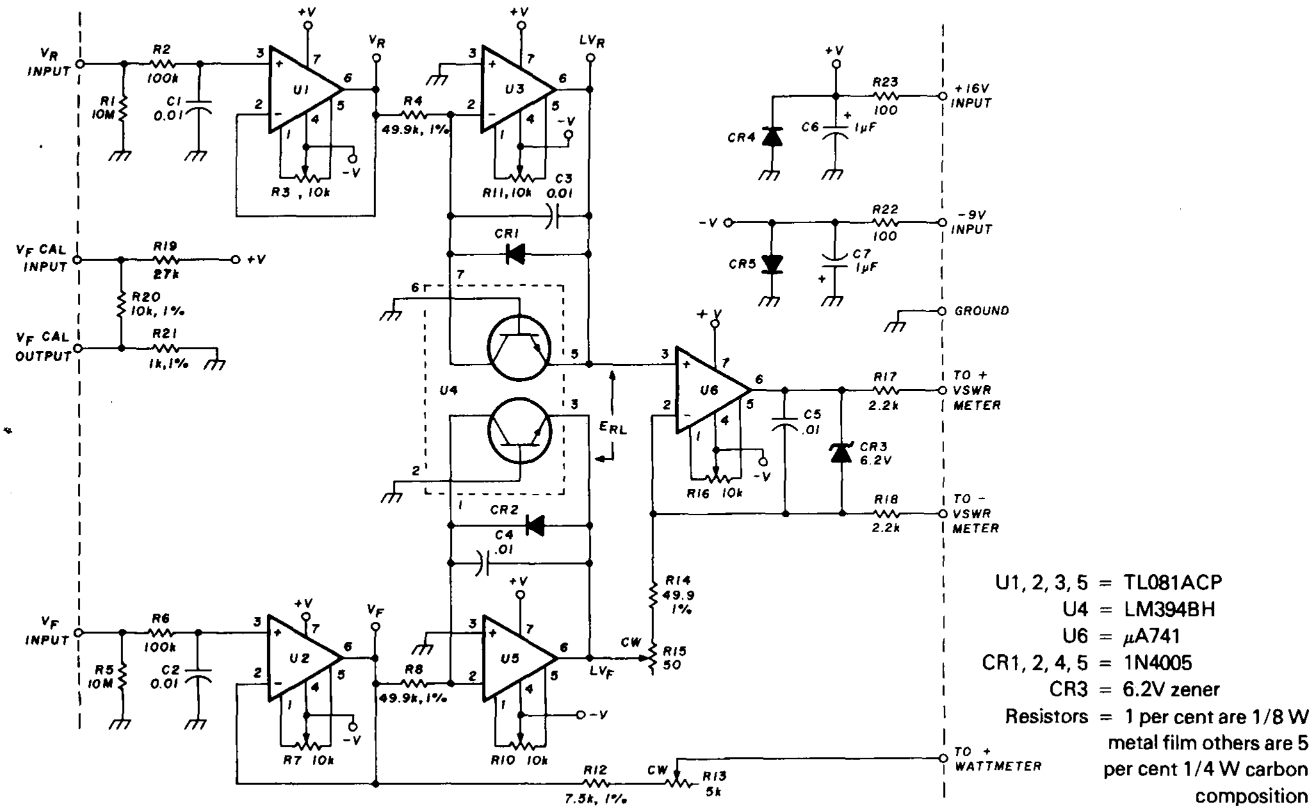


fig. 5. Analog circuit schematic.

allows instrument calibration and operation to be verified at regular intervals. The calibration is verified by the voltage ratio from resistor divider *R20* and *R21*, **fig. 5**. The voltage ratio in this case is 0.091, which is equal to reflection coefficient ρ. A ρ of 0.091 is equal to a VSWR of 1.2:1. During normal operation V_F and V_R inputs come from the directional coupler, but when the check switch is put in the CHECK position, V_F and V_R inputs are connected to the known voltage ratio corresponding to a VSWR of 1.2:1. This known voltage ratio is used to calibrate the instrument.

The V_F *Cal* voltage is a measure of the battery voltage. As such it appears on the wattmeter in watts. Accuracy isn't excellent, because the wattmeter calibration affects the actual *V-to-watts* reading; however, it's an excellent first-order reading of the battery voltage. On this 250-watt scale, a low battery voltage reading is approximately at 40 watts.

construction notes

Construction of this instrument requires no special techniques to achieve success. A wiring diagram appears in **fig. 6**. Construction isn't detailed because anyone experienced in construction should be able to meet the parts and fabrication requirements.

One area of concern is shielding. The analog board and power ON/OFF board have high impedances, so care must be taken to make sure these boards are not exposed to rf. Except for external rf pickup, there are no critical layout areas inside the instrument. The shielded directional coupler is essential so that it may be located inside the instrument (see **fig. 3**).

The meters used are readily available from Radio Shack, part 22-052. I made a three-to-one scale of the meter face, then had it photographically reduced to fit on the scale. The scale photograph was then attached to the Radio Shack meter scale by double-sided tape. I removed the original scale from the meter, attached the new scale to it, and then replaced the scale, securing it with the two mounting screws.

Six 1-per cent metal film resistors are called out for the analog board. Availability may be a problem, so here are some possible alternatives with expected performance changes. *R4* and *R8* must be a matched pair for logarithmic tracking. Thus the actual value is not critical, and they could be carbon film resistors if they are matched to 1 per cent. *R14* and *R12* are metal film resistors only to minimize temperature influence and could be carbon film.

R20 and *R21* must be selected to be within 1 per cent of the absolute value, because these two resistors determine the basic accuracy of instrument calibration. I encourage the builder to find 1 per cent

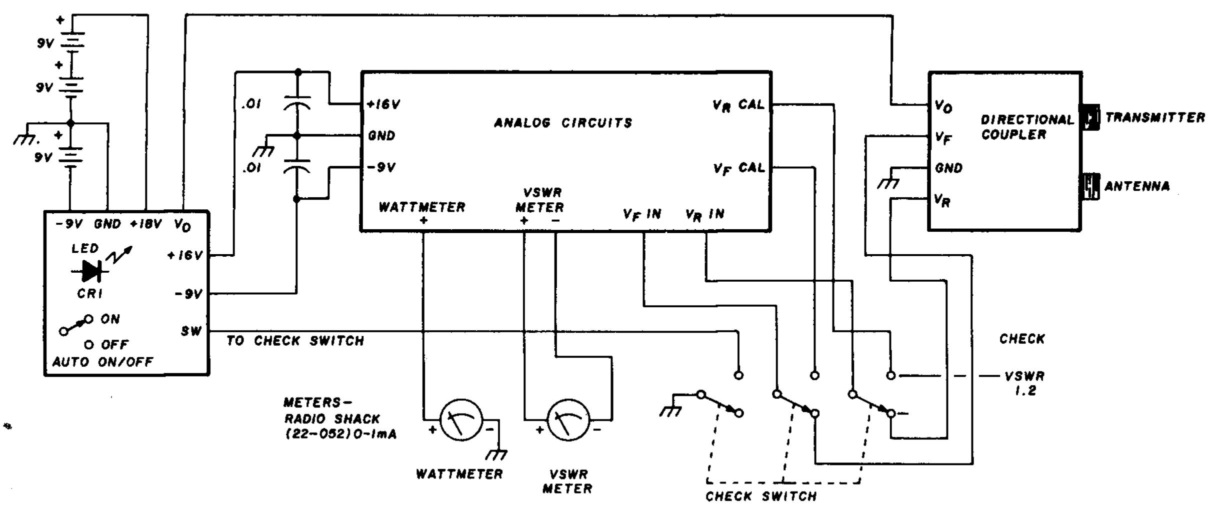


fig. 6. Wiring diagram.

metal film resistors if at all possible. If carbon film resistors are used in any of the 1-per cent metal-film resistor slots, some performance degradation will occur as a function of temperature.

Us 3 and *5* must be in sockets to allow for adjusting the offset trim pots for the operational amplifiers. Also test points for V_R, V_F, LV_R, and LV_F will allow for easy testing and calibration of the analog board.

calibration

Calibration of the instrument is in two parts, rf and dc. The directional coupler can be calibrated before installation in the instrument; the procedure was covered in the discussion on the directional coupler. Refer to **fig. 5** for the following procedure:

1. With *U3* and *5* removed from their sockets, ground the V_O output of the directional coupler and turn on the instrument. The amber LED pilot light should glow, indicating power is being drawn by the analog board.

2. Connect test points LV_R and LV_F together with a jumper lead.

3. Adjust *R16, U6 offset adjust* for "∞" on the VSWR meter (normal meter zero).

4. Disconnect jumper from test points LV_R and LV_F. Connect voltmeter to V_R and adjust *R3, U1 offset adjust* for zero volts ($< \pm 5$ mV).

5. Connect voltmeter to V_F and adjust *R7, U2 offset adjust*, for zero volts ($< \pm 5$ mV).

6. Turn off instrument and install *U3* and *5*.

7. Connect voltmeter to test point LV_R and ground. Turn instrument on and adjust *R11* for approximately -0.30 volts. Then adjust *R10* for "∞" on VSWR meter. There will be some interaction, so repeat adjustments of *R11* and *R10* until voltage test point LV_R is -0.30 volts and VSWR meter is "∞".

8. Set check switch to 1.20 VSWR, check position, and adjust *R16* for a VSWR reading of 1.20.

9. Return check switch to NORMAL or OFF position and note that voltage at test point LV_R is still about -0.30 volt. With no inputs to the analog board from the directional coupler, the voltage at test points LV_R and LV_F will drift around due to the extreme low currents into the logarithmic amplifiers. This is normal. When the dc signals from the directional coupler are present the logarithmic amplifier outputs will be stable.

10. Turn instrument off and disconnect voltmeter and jumper wire that grounded V_O from directional coupler.

11. Connect input side (TRANSMITTER) of directional coupler to transmitter and output (ANTENNA) side of directional coupler to a good wattmeter and dummy load. With an applied rf power of between 100-250 watts, adjust *R13* so that the instrument wattmeter reads the same as the external wattmeter. Calibration frequency isn't critical, but I usually use the 40-meter band as a midrange frequency.

performance

Wattmeter accuracy is primarily determined by the design and construction of the directional coupler. In this instrument, the wattmeter accuracy is ± 5 per cent reading $+1$ per cent full scale between 1.8 and 30 MHz. The VSWR measurement accuracy is difficult to specify, because several factors affect the measurement. For VSWR greater than 2, the directional coupler open-short ratio dominates the VSWR error.

This directional coupler measures an open-short ratio of 0.6 dB, which translates to an error of 7.5 per cent at a VSWR of 6. A complete discussion of the open-short ratio can be found in an instruction book for the ANZAC Model RB-3 standing-wave-ratio bridge, dated March, 1966.[2] For VSWR less than 2, directional-coupler isolation is a dominant factor with the detector diode operating-voltage level.

The isolation of this directional coupler is about 30 dB. The analog circuit dynamic range exceeds that of the detector diodes and isn't a factor in VSWR accuracy. As with any diode detector, a minimum level of ac signal is required before any dc current will flow. Also since the diodes are in the peak detecting mode, there's a minimum level of ac signal where the diode dc current will be accurate with respect to the ac signal peak value. Therefore, a minimum amount of signal is necessary to obtain accurate readings.

In this instrument, the minimum forward power required to obtain an accurate ± 10 per cent VSWR at various VSWR numbers is:

1. 2.5 watts for VSWR = 2.0.
2. 5 watts for VSWR = 1.5.
3. 25 watts for VSWR = 1.2.
4. 35 watts for VSWR = 1.12.

You may ask what it means if the VSWR meter reads more than 1.2 with 25 watts input. It means that the VSWR is better than 1.2 but the actual value isn't known. To put it another way, at any power level a minimum VSWR number is accurate, and any lower number is optimistic. This minimum power for an accurate VSWR number is characteristic of all directional couplers using diode detectors; however, it's usually not specified nor mentioned as a limitation in VSWR measurement.

Performance is more than adequate for quick and accurate measurements of a typical transmitter power output and how well it is matched to the load.

VSWR measurement

Numerous articles correctly state that VSWR in a transmission line is not an important parameter to keep low in value, and that only upper-limit numbers are of concern based on transmission line loss and other factors. So why is there still concern about VSWR?

One aspect of the measurement sometimes overlooked is that a *reference impedance* is involved. The VSWR measurement is only valid for the reference impedance for which it has been designed, in this case 50 ohms. Common practice is to define system performance with reference to a system impedance. Also common practice for Amateurs is to use a 50-ohm dummy load for tune up. In doing so, the 50-ohm reference is established, and if all other measurements are relative to this 50-ohm reference, the results will be valid. If VSWR measurements are made in which the reference impedance is other than that of the instrument, the results will not be valid, and a correction must be made.

I feel that until a readily available means of measuring power transfer independent of impedance is available, the VSWR meter will continue to be a valid means of determining system performance. Plate-current meters on most transceivers allow a first-order means for measuring power transfer. Careful use of these meters can provide successful results. But I've never been quite as satisfied with this method as with the use of the external power and VSWR meter, using a transmatch to couple the antenna and a 50-ohm dummy load for reference.

conclusion

This article has several objectives. One is to give complete details on how my automatic VSWR meter design works so that others can understand its operation and use. Another is to provide design equations and show their use in the design of a commonly used directional coupler. Finally, it was desired to provide construction details for duplication of the instrument.

This automatic VSWR/power meter is a project I've been working on for more than two years. I'd like to thank fellow Amateurs who've encouraged me and given valuable advice. With their help I've developed what I believe is a very useful station accessory.

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ham radio

experimental
high-gain phased array

Some interesting test results using phased colinear elements based on the "ZL Special"

Since the construction of the ZL beam[2], I've been intrigued by the possibility of producing another noticeable improvement in antenna performance. After reviewing the literature, several options seemed available. First, one could duplicate the antenna and stack it over the present assembly. Secondly, one could stack the antenna in a side-by-side arrangement. Both arrangements should produce a 3-dB change in antenna performance. However, the cost of construction would be enormous, as would the cost of strengthening the support structure.

These options were discarded for economic reasons, and I continued to search the literature. After some thought, the following question came to mind: Why not extend the lengths of the ZL elements into full-size, half-wave elements and feed it as if it were a ZL Special?[1,2] The following report gives the results of the experiment.

description

Fig. 1 shows the basic construction. Nine half-wave elements were constructed consisting of four driven half-wavelength elements E_B, E_A, collinear reflector R, and collinear director D_1. Yagi director D_2, 1/2 wavelength long and spaced 1/4 wavelength from D_1, was also constructed. Two phasing stubs were connected to points A, B. This basic configuration was alternately fed at these points for the tests (**figs. 2** and **3**). The parasitic elements were tuned and relative field-strength patterns were obtained as shown.

Reversing the A-B feed changed the action of

By Jim Weidner, KL7IEH, S/R 50937, Fairbanks, Alaska 99701

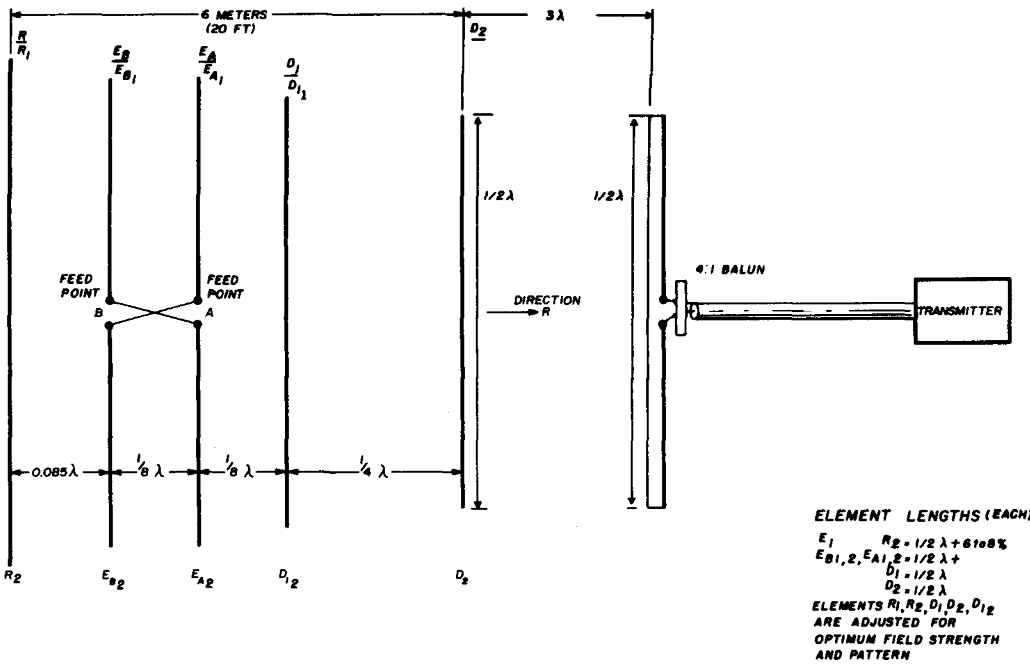


fig. 1. The basic construction used in the experiments with the phased array.

phased elements to such an extent that the action of the parasitic reflector element was overwhelmed, which in **fig. 3** had been tuned for maximum radiation in direction R.

tests

The test using feed point A (**fig. 2**) produced the best results. A 15-meter model was made, and performance was good. However, it didn't "feel right." Subsequently, a model was made for 10 meters and operated by a friend, who reported results not much better than those obtained from a regular Yagi. Again, the literature was searched and I discovered that element E_A must have *opposite* polarity with respect to element E_B.

Once more the literature was reviewed, and a new *question arose: Is there a way to connect the elements so that when a wave is emitted from* E_B, it will coincide simultaneously with a wave emitted from E_A when E_A and E_B are 1/8 wavelength apart? The literature suggested that a 5/8-wavelength piece of coax, fed at the 1/8-wavelength point, would pro-

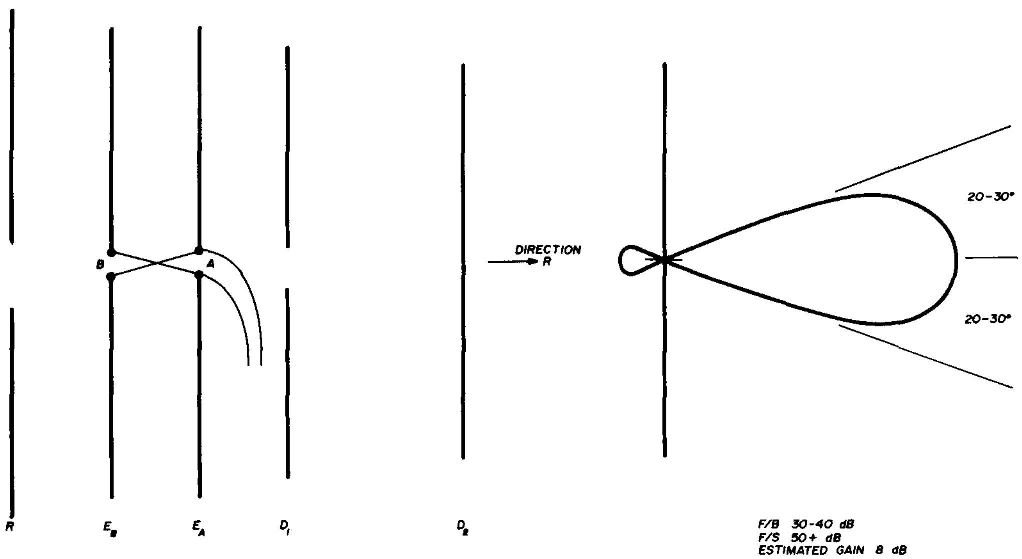


fig. 2. Response when feed point A was used, which produced the best results.

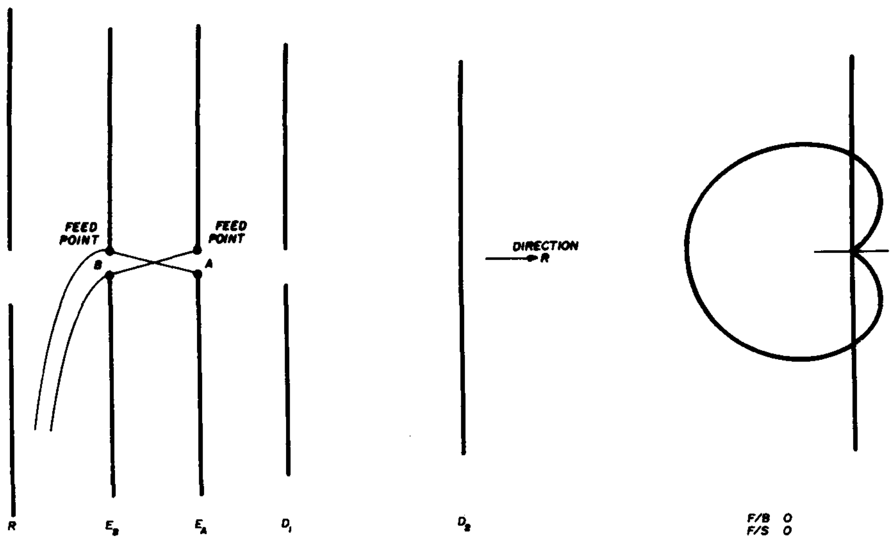


fig. 3. Reversing the A-B feed point changed the pattern dramatically, because the parasitic reflector element was overwhelmed.

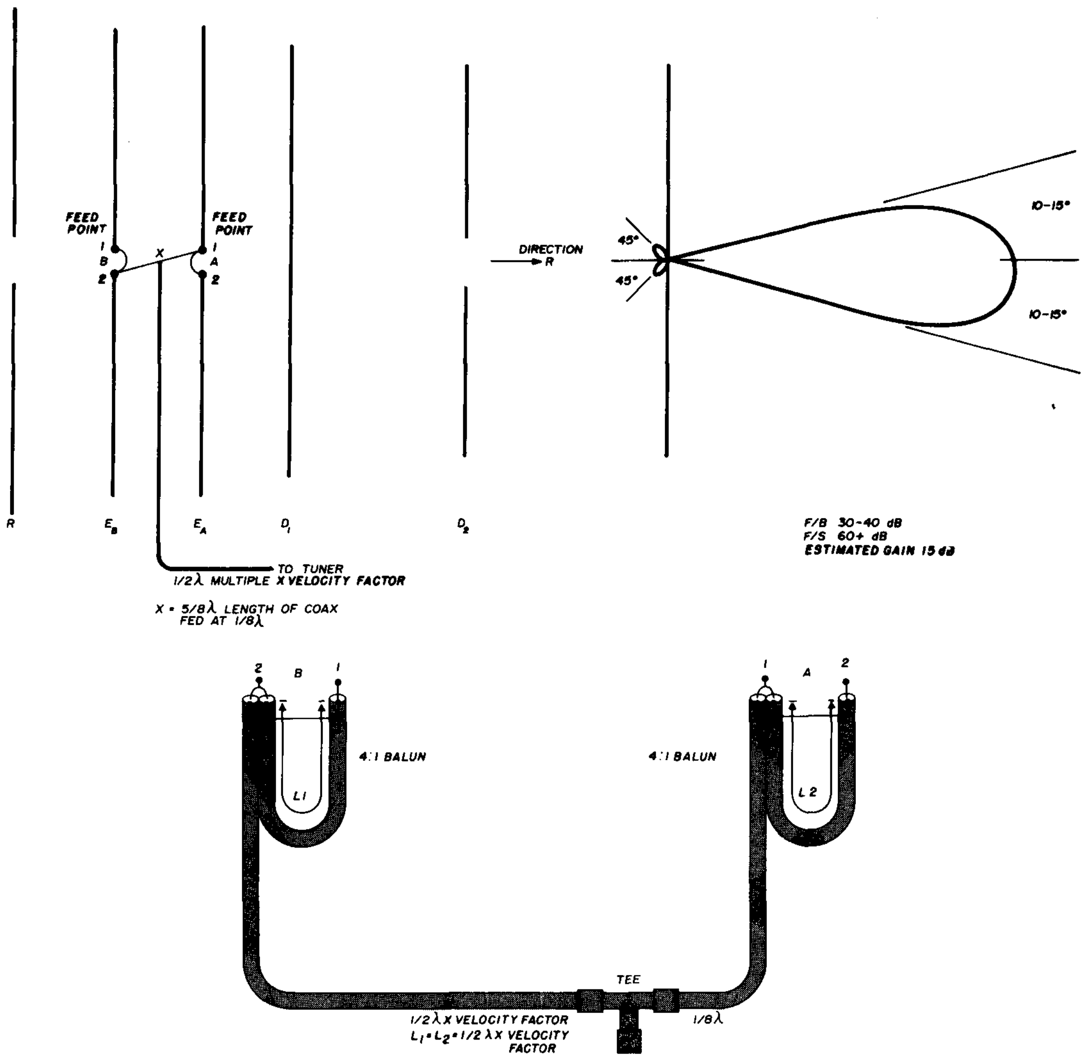
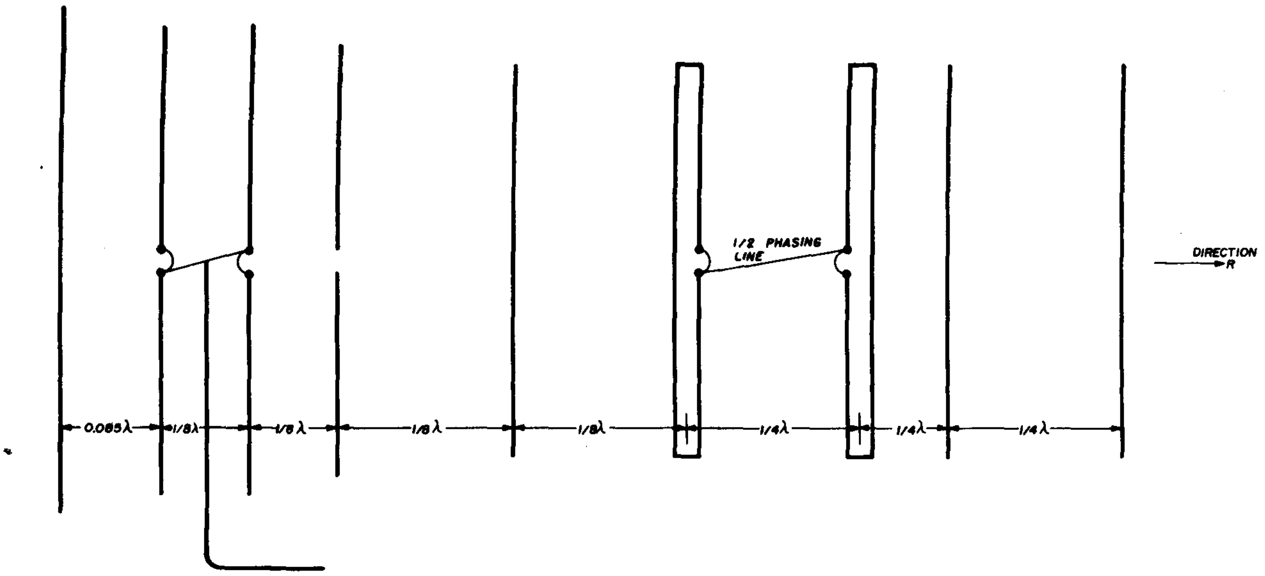


fig. 4. Adding a phasing harness between feedpoints B and A resulted in a large increase in response.



vide the correct phasing, so that waves emitted from E_B would coincide with those emitted from E_A and remain coincident with direction R. I added a 4:1 coaxial balun on each end of the phasing harness to maintain balance and permit polarity reversal (**fig. 4**).

Before installing the phasing harness I made a relative field strength reading using the arrangement in **fig. 2**. I then connected the phasing harness as in **fig. 4**. To my astonishment, the phasing harness produced a 1 - 1-1/2 S-unit increase in relative field strength, or an estimated 5-7 dB improvement in antenna gain. I tweaked the parasitic elements, and the pattern of **fig. 4** was obtained. The length of reflector R is what would be expected in a normal Yagi. Directors D_1 and D_2 are shorter than the calculated value and are somewhat critical in adjustment.

On-the-air tests of the arrangement in **fig. 4** suggested noticeable improvements — F/B was around 40 dB; F/S was 60 dB or more. Forward gain over a dipole, as suggested by the pattern, indicated 15 dB. Antenna bandwidth is approximately 500 kHz on 10 meters. The pattern is clean except for two small lobes off the back (when operated at ground level).

future experiments

Plans now are to modify a 20-meter beam by installing four halfwave elements in phase with parasitic elements and to explore the possibility of operating the parasitic directors as phased couplets, as shown in proposed test arrangement of **fig. 5**. Also, there seems to be no reason why the arrangement of **fig. 4** can't be applied to quad antennas with the same results.

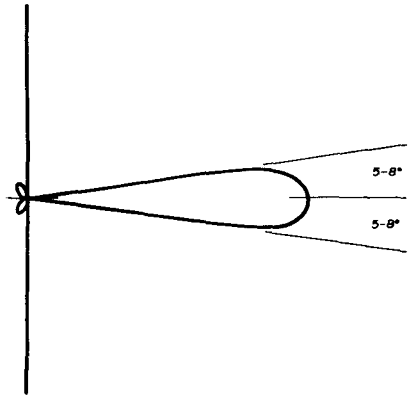


fig. 5. Future plans for four halfwave elements in phase with parasitic directors operating as phased couplets. Beamwidths shown at the half-power points.

acknowledgments

I wish to thank Dennis Timm and my daughter Lynnette, who helped with various measurements and adjustments during the antenna experiment. Also thanks to my wife, Shirley, who typed the manuscript.

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- MB-100 mobile mounting bracket

10-meter ZL Special antenna for indoor use

Hampered by real-estate restrictions or a grouchy landlord? Try this full-size rotatable array that fits into an average room

To an Amateur, a huge antenna array high in the sky is beautiful. But more and more of us must live where outside antennas are frowned upon or forbidden. We're then faced with two choices: forego hf operation or use some sort of indoor antenna. I find the first choice unbearable. As for the second, antenna manufacturers, antenna handbooks, and Amateur-magazine articles offer little except loaded dipoles, loaded verticals, or random wires zigzagging like crazed snakes. Fortunately, there's no need to struggle with such inefficient antennas. Antenna theory applies equally well whether an antenna is located indoors or high on a mountain peak.

I live on the second (top) floor of a wood-frame, brick veneer apartment building. I operate from my bedroom using a full-size, rotatable, two-element, 10-meter, *indoor* ZL Special beam.[1] Just about anyone with a few simple hand tools and about $15 for materials can duplicate my antenna in a few hours.

why a ZL Special?

The ZL Special[1] is an all-driven array consisting of two unequal-length folded dipole elements spaced at 0.125 wavelength and fed 135 degrees out of phase. The array is unidirectional and has about 6 dBd forward gain and a good front-to-back ratio. The ZL Special is an old design and not currently in vogue. I suspect that its mechanical complexity, when constructed from aluminum tubing for outdoor use, and the fact that it's a single-band device have detracted from its popularity. My experimentation with it and several other antennas has uncovered a number of very good reasons for making the ZL Special the antenna of choice for indoor use.

The usual ways to squeeze an antenna with a 5-meter (16.5-foot) span into a 3.7 × 3.7 meter (12 × 12 foot) room, are a) to use loading devices, or b) bend the elements to fit the available space. Within reason, the ends of folded dipole elements may be bent without appreciable loss.

All antennas are adversely affected by unwanted coupling to nearby objects. Indoor antennas are generally close to house wiring, heating ducts, and other objects, and tend to couple energy to them. This problem is manifested by resonance shifts, drastic VSWR changes, and reduced gain and directivity. All-driven arrays, particularly those with folded dipole elements such as the ZL Special, are less troubled by unwanted coupling than are parasitic arrays. Quads are too large, even when reduced in size by loading, to be used indoors.

The ZL Special is a low-Q, hence wideband-response, array which is fairly tolerant of element length and spacing. Array impedance is about 70 ohms, compared with about 20 ohms for a parasitic Yagi. The ZL Special can be fed with 75-ohm coax using a simple sleeve-type bazooka balun.

A variation of the ZL array uses 0.375-wavelength elements, which reduces the antenna span by 25 per

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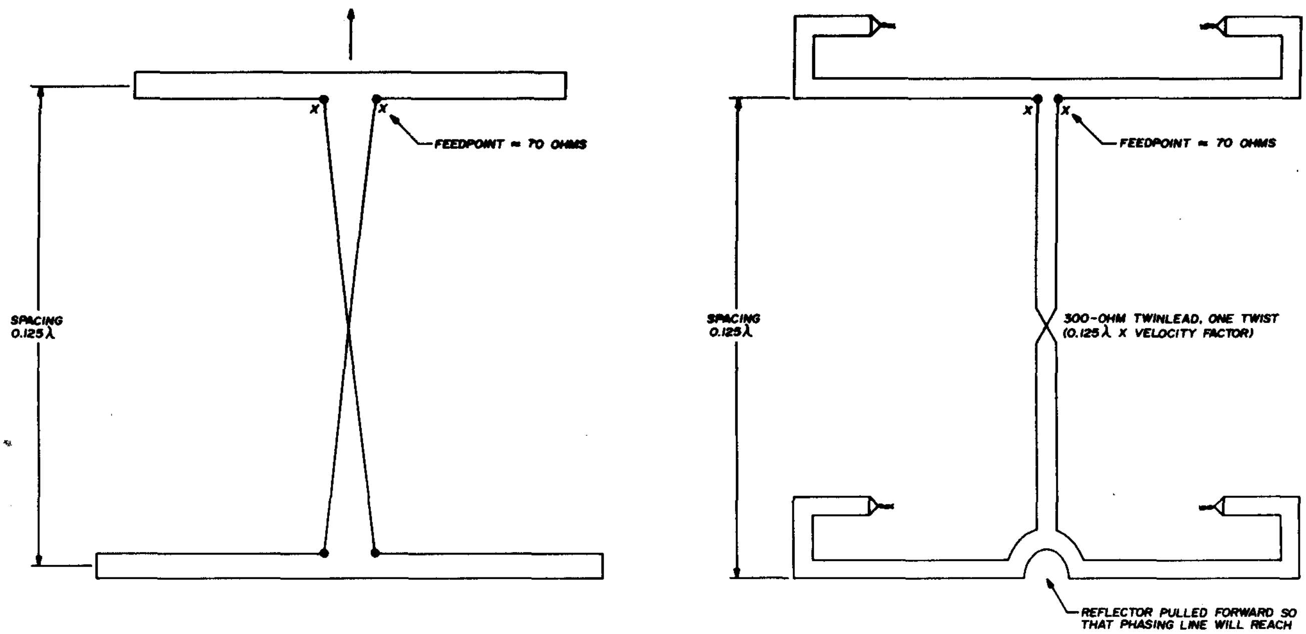


fig. 1. The ZL Special all-driven array is usually made of aluminum tubing and is cumbersome (*left*). Use TV twinlead with the ends bent to fit your available space, and you have the indoor ZL Special (*right*). The twinlead version has a phasing line shorter than the space between elements, and the rear element must be bowed forward slightly to connect the phasing line.

cent (described later). Spacing can be reduced to 0.1 wavelength. A 15-meter shortened ZL Special is about the same size as a standard 10-meter version and has only slightly less gain. A similarly reduced 20-meter array will fit a large 5.5 × 5.5 meter (18 × 18 foot) room or attic.

Attempts to use more than two elements, or to build multiband arrays indoors, are likely to be rewarded with less-than-hoped-for gain or with an array that performs poorly on several bands. I prefer one good antenna for my favorite band. I use temporary indoor dipoles for the other bands.

which design?

Dimensions for ZL Specials are many and varied.[2] Element length depends on the type of construction. The vertical portions of the indoor ZL Special may act as capacitance hats and reduce the element length. These are dimensions I found to give the best results for a 10-meter array:

$$\begin{aligned} \textit{director length} &= 135/f \text{ meters } (444/f \text{ feet}) \\ \textit{reflector length} &= 144/f \text{ meters } (472/f \text{ feet}) \\ \textit{spacing} &= 37.2/f \text{ meters } (121/f \text{ feet}) \\ \textit{phasing line} &= \textit{spacing} \times 0.82 \text{ (velocity factor)} \end{aligned}$$

where f is frequency (MHz).

Using a design frequency of 28.7 MHz gives a director length of 4.7 meters (15.5 feet), reflector length of 5 meters (16.5 feet), spacing of 1.3 meters (4.3 feet), and a phasing line of 1.1 meters (3.6 feet).

With no weather problems to contend with, the indoor ZL (**fig. 1**) uses lightweight wood for the boom and element supports. An earlier version used PVC pipe, which performed as well as the wood version, except that the PVC is flexible and it flopped when rotated and struck the walls and ceiling.

construction

Select unwarped, knot-free, pine 1 × 2 lumber and redwood furring strips. Cut to size (**fig. 2**) and give the wood pieces two coats of paint. (I chose to match the color of the walls and ceiling.) Hardware is steel angle brackets and mending (reinforcement) plates, which are inexpensive and available at any hardware store. The boom is attached to the TV mast with a U bolt.

I found it easier to build and make the initial beam assembly on a flat surface (living room floor), then reassemble it at the operating site. If you use machine screws to attach the hardware, you can assemble or disassemble the array in about ten minutes. (Quick disassembly avoids questions about the "clothesline" by guests — or the landlord!)

The idea is to have as much of the elements oriented horizontally as possible, so the framework dimensions are flexible. Figure on at least 7.5 cm (3 inches) wall-to-crossmember clearance. The boom length controls the spacing and should not be changed. The vertical end pieces can be reduced to as little as 30 cm (1 foot) to increase headroom, but the element length may have to be increased.

I built a simple, sturdy base from two 31 × 62 cm

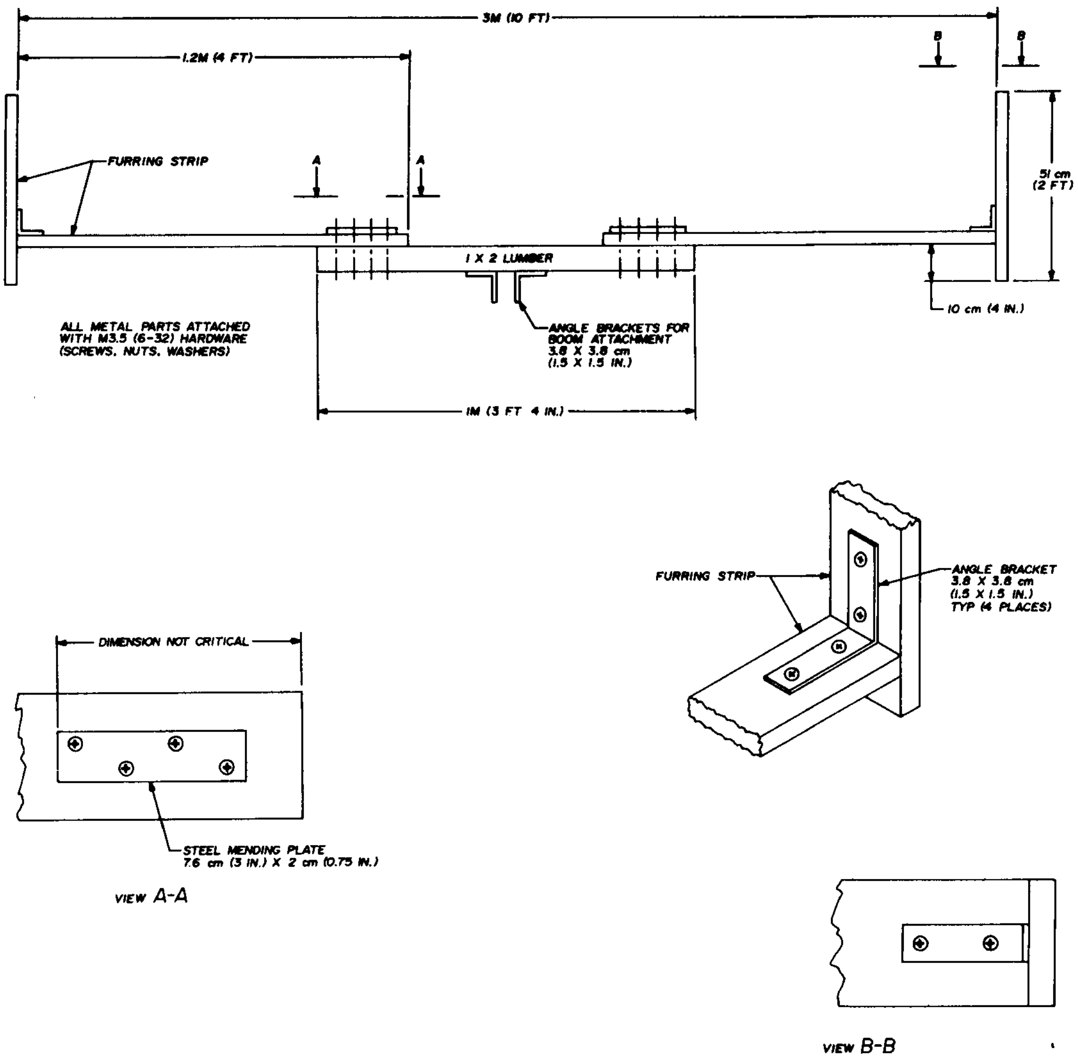


fig. 2. Crossmember construction. Two identical crossmembers are required. Pine 1 × 2 lumber and redwood furring strips provide a lightweight but strong structure. When the elements are in place, the structure is braced by the top guy wires and doesn't sag or flop around when rotated.

(1×2 foot) pieces of particle board (**fig. 3**). One board is flat on the floor and the other is vertical. A pair of TV mast clamps hold bearings (PVC pipe couplings) to allow mast rotation. A PVC pipe cap or an empty mayonnaise jar will serve as a bottom bearing. The base is steadied by clamping it to a solid object or by setting a couple of concrete blocks on the horizontal board.

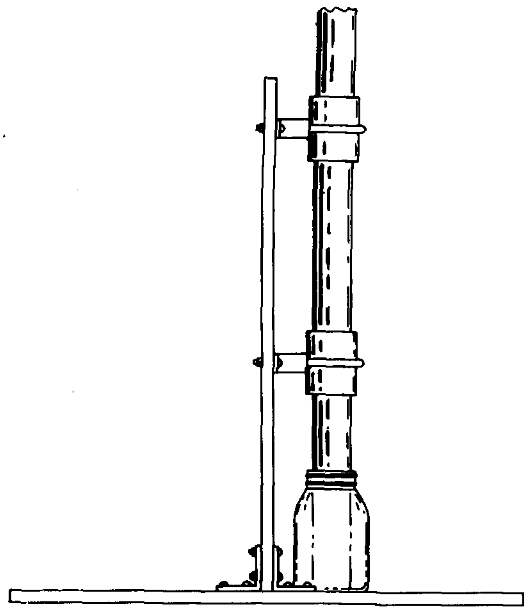
The elements are made from heavy-duty, foam-filled TV twinlead. The elements are looped around the vertical end pieces (taped in place) and strung across the top with wire or twine. Elements and top wires form a box at each end of the array. At moderate power, no additional insulation is required. PCB material with the foil removed makes excellent insulators. I used WA6TKT's method of bowing the reflector forward to fit the phasing line length.[3]

feeding the array

The feedline RG-59/U should be a multiple of 0.5 wavelength. A simple bazooka (sleeve balun) is formed by slipping a 0.25 wavelength piece of shield braid, removed from RG-8/U or RG-11/U, over the antenna end of the feedline, **fig. 4**. The braid is soldered to the feedline shield at the 0.25-wavelength point, and no other connection is made to the braid. Wrap the braid with vinyl tape. The bazooka length is 2.6 meters (8.5 feet) for 10-meter operation.

performance

Performance data for my indoor ZL Special antenna appear in **figs. 5** and **6**. Gain, front-to-back ratio, and VSWR (**fig. 5**) are for a direction not affected by unwanted coupling. Proper performance of duplicate antennas is indicated by a VSWR minimum at the



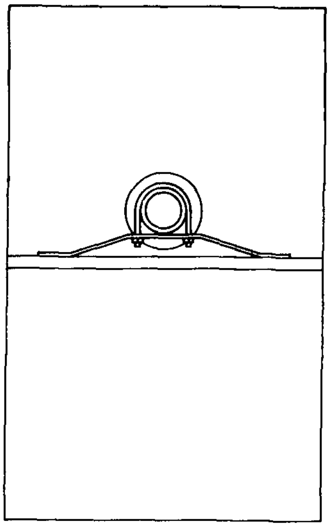
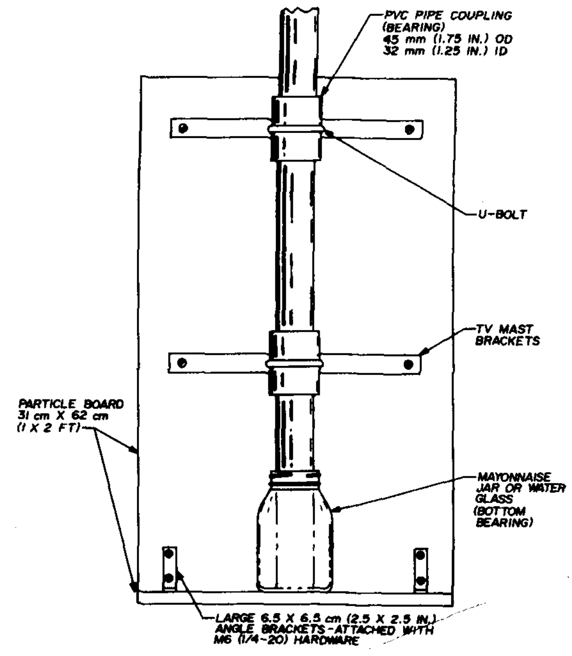


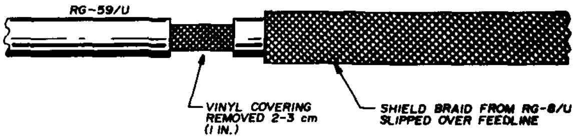
fig. 3. A simple but strudy base for the indoor array is made from two pieces of particle board or similar material and standard TV mast brackets. Total cost of the base is about $6.00 exclusive of the mayonnaise-jar bottom bearing.

design frequency (approximately 28.7 MHz). The front-to-back ratio is a function of phasing-line length, while gain is related to element spacing. Exhaustive pruning is probably not worth the effort once the array is working satisfactorily.

Fig. 6 shows VSWR variations of my array as it's rotated. The variation is caused by coupling to metallic objects in the room. A parasitic array (an early attempt) had a peak VSWR of 6:1 in the direction of the air-conditioning duct. Metal objects more than 0.25 wavelength distant don't cause resonance shifts or VSWR variations.



The difficulties of accurate measurement inherent to high-frequency arrays are compounded when the array is indoors. Repeated measurements using various techniques indicate a forward gain of about 6 dBd and a front-to-back ratio of 15-18 dB. The pattern is a cardioid and has a deep rear notch. VSWR is low over the entire 10-meter band and causes no problem for solid-state finals. I've checked the observed beam headings of hundreds of stations against a great-circle chart and found no significant errors. The only real difference between an indoor array and one outdoors is that the indoor array can be rotated in seconds rather than minutes.



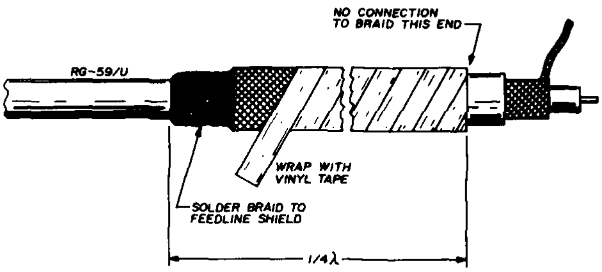


fig. 4. A simple bazooka balun: no impedance transformation, but it helps to eliminate feedline radiation. Aluminum foil could be used to wrap the coax, but the shield braid removed from larger coax makes a neater balun. Coax that's too lossy for a feedline is a good shield-braid source.

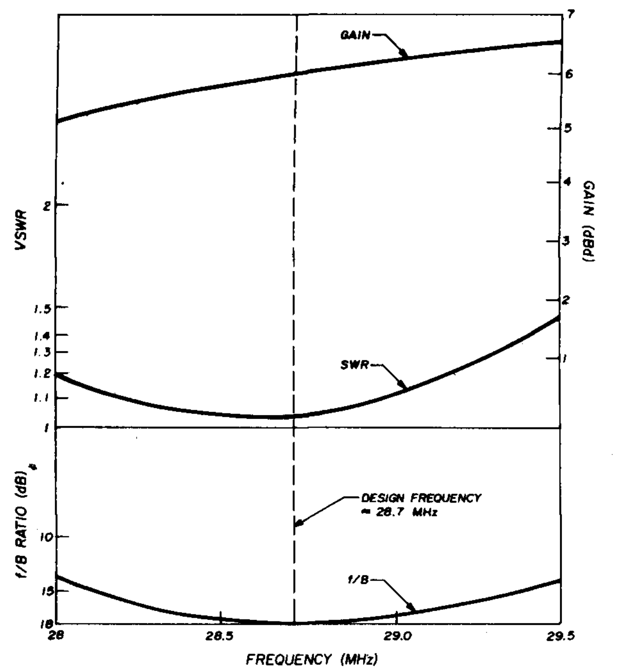


fig. 5. Indoor ZL Special performance data. The data are for a direction not affected by unwanted coupling. Design center is 28.7 MHz.

another version

A shortened version of the antenna is shown in **fig. 7**. It's a bit more complex, but the elements are 25 per cent shorter than in the design described above. It may be spaced 0.1 wavelength to decrease boom length but with some sacrifice in gain.

Element lengths are determined by the data given previously, multiplied by a factor of 0.75. For example, the director length for a design frequency of 28.7 MHz would be:

$$\begin{aligned} \textit{director length} &= \frac{135}{28.7} \times 0.75 \\ &= 3.5 \textit{ meters } (11.5 \textit{ feet}) \end{aligned}$$

The element ends may be bent up and around as shown in **fig. 1B**. My measurements of this shortened ZL Special were: gain approximately 5 dBd; front-to-back ratio about 12 dB.

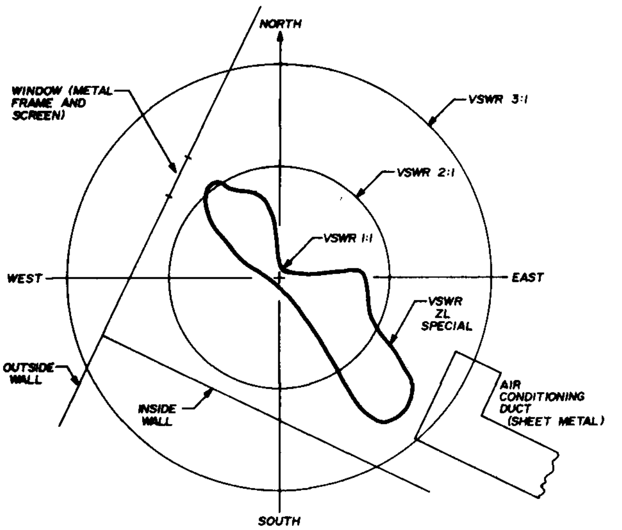


fig. 6. More performance data on the 28.7-MHz indoor array. Shown is VSWR variation as the array is rotated — the variation is caused by surrounding metallic objects.

concluding remarks

The indoor ZL Special is far and away the best indoor antenna I was able to construct in two years of trying. With the indoor ZL, stateside contacts are 3 to 4 S-units better than my next best indoor antenna, phased groundplane verticals. During a recent 48-hour contest period, I worked 21 different countries on all continents using a barefoot Ten-Tec Argonaut, 3 watts PEP output!

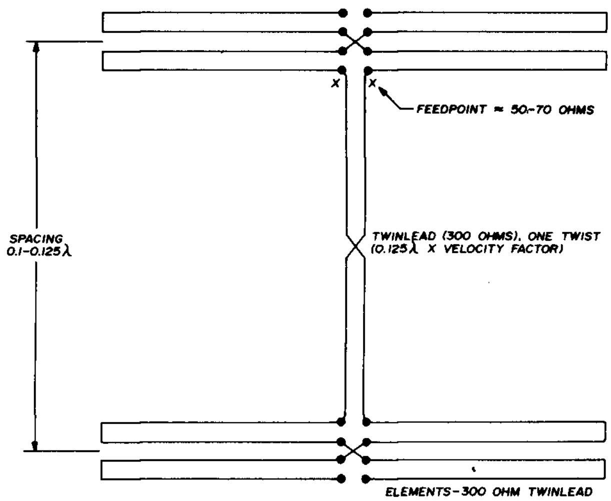


fig. 7. A shortened ZL Special. Spacing may be spaced 0.1 wavelength to decrease boom length. This small antenna provides about 4-5 dBd gain.

I hope nobody is naive enough to think that the performance of an antenna can be improved by placing it indoors; but neither should it be believed that indoor antennas cannot work. The multitude of variables make it impossible to predict how well an indoor array will perform at your location, but the indoor ZL Special is sure worth a try.

references

1. *The ARRL Antenna Book*, American Radio Relay League, 10th edition, 1964, page 214.
2. Pat Hawker, G3VA, "Amateur Radio Techniques," Radio Society of Great Britain, London, 6th edition, 1978, pages 251, 252, and 273.
3. Gary Blake Jordan, WA6TKT, "Understanding the ZL Special Antenna," *ham radio*, May, 1976, pages 38-40.

ham radio

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Input impedance:	10 megohms, DC/AC volts
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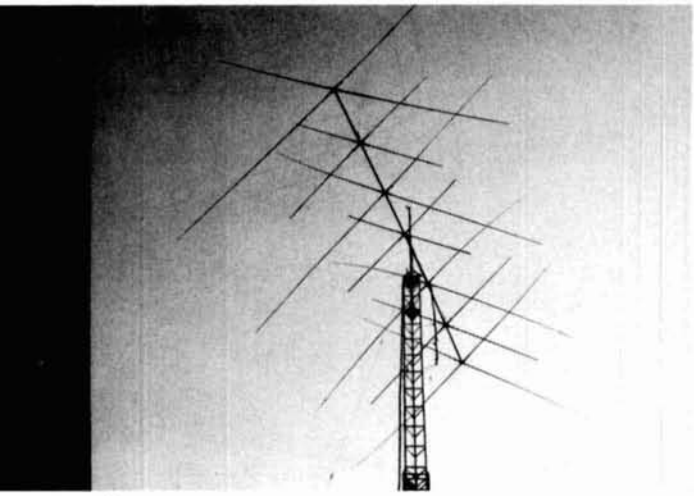

big quad — small yard

Here's how one Amateur erected a three-band quad antenna on a modest-size residential lot

Let me begin by saying that there are a few time-honored maxims about Amateur antennas. First, the result will be in direct proportion to the amount of time, effort, and money expended. Second, there's no such thing as too high or too big. Third, if the antenna stays up through the winter, it's not big enough!

With this philosophy in mind, I decided to build a big quad antenna with four elements on the Amateur 15- and 20-meter bands and seven elements on the 10-meter band, all on an 8.5-meter (28-foot) boom. The entire array was to be installed in a modest California backyard on a tilt-over tower.

The following is a photo essay on the project. I hope it will inspire others with a small yard to bite the bullet and put up a big antenna.

background

Last year I acquired a 21-meter (70-foot) guyed crank-up tower. With my mast it would allow the antenna boom to be nearly 23 meters (75 feet) up. Also it looked strong enough to handle something much larger than my old cubical quad on a 2.7-meter (9-foot) boom. I brooded, plotted, and schemed all winter, which, in southern California, is marked by windstorms up to 112 km (70 miles) per hour for a four-month period. I'd built a four-element quad for 15 and 20 meters the previous year and it worked great, but the place where the two boom lengths were joined together was weak and bent in the wind; thus the end of the four-element quad.

For six years I've been constructing and erecting quads in my back yard. And for six years, trees and bushes have been growing, cutting down the available space. Even so, I decided to build a quad with four elements on 15 and 20 meters and seven elements on 10 meters — all on an 8.5-meter (28-foot) boom.

This arrangement would give 0.13-wavelength spacing on 10 and 20 meters and 0.20-wavelength spacing on 15 meters. My experience indicated that these were acceptable spacings for the bandwidth and gain I was seeking. The antenna for each band would be fed directly through a gamma match, and all three coax cables would be run down to the station. I decided to use two reflector elements on 10 meters. (This should improve the front-to-back ratio

By George McCarthy, W6SUN, 2739 North Atherwood Avenue, Simi, California 93065

fig. 1. View from author's patio roof showing the work area.

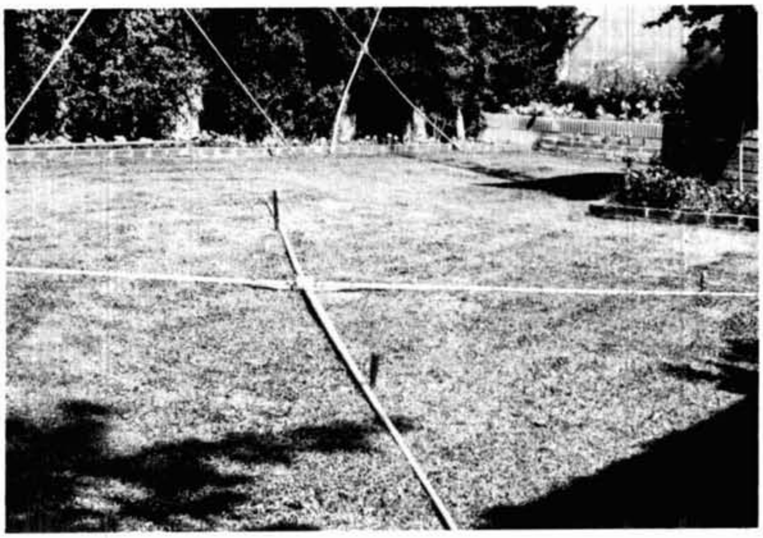

fig. 2. Method of assembling quad spreaders and elements.

fig. 3. Tower tilted over with mast and rotator installed and quad spreaders all over the place.

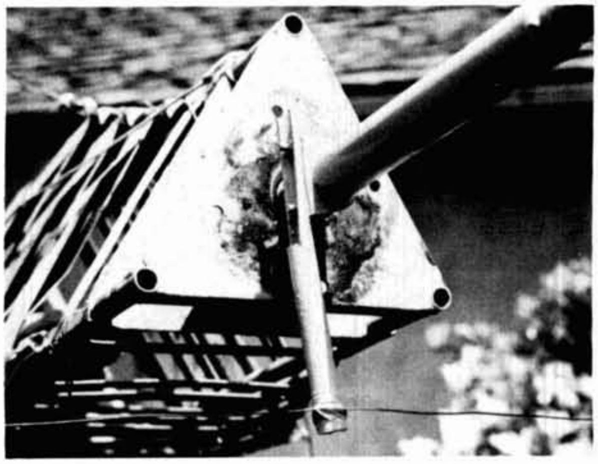

fig. 4. A length of PVC pipe, bolted to the mast with a muffler clamp. Ten-meter director wire is taped to the other end.

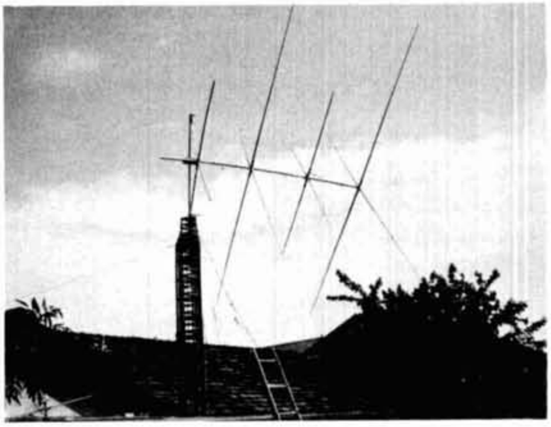

fig. 5. The "big quad — small yard" secret. Tower is raised and array is turned around.

fig. 6. Assembly of the other end of the antenna. Driven element is in place; the 10-meter reflector is next. The second reflector is installed last.

a bit and allow me to string all three driven elements on the same spreaders, which was convenient.)

putting it up

The photos pretty much tell the story of how I managed to erect such a monster in a small area. I'll now relate some of the sidelights of the job.

I did all the work myself with one exception: the tower must be pulled over by someone else until gravity takes over and I can let it down with a winch. My thanks to Bob, W6TSH, and Joe, W6UL, who came over to help with this task.

A boat winch is the secret of my solo performance. The aircraft cable from the winch runs over the peak of the roof to the tower. That's right — I use the peak of the house as a gin pole! I figure that if anything goes it'll be the house. I raise and lower the tower from this position, which entails a lot of stopping and running around to make sure the wire isn't hung up on something.

From long experience, I no longer rely on predrilled holes in the fiberglass spreaders — they wear with wire movement. I stuck screwdrivers into the lawn to keep the spreader arms from distorting the perfect square. Then I ran the wires around the screwdrivers, moving the screwdrivers until I had a nice, tight loop that wouldn't pull the spreaders. I then taped the wire to the spreaders with PVC tape and applied PVC cement to keep the tape secure.

The short boom section connected to the boom-to-mast adapter is 1.4 meters (4-1/2 feet) long. It has a 4.8-mm (3/16-inch) wall, which I turned down slightly for a distance of 152 mm (6 inches) at each end. The aluminum booms, which are 3.7 meters (12 feet) long and 51 cm (2 inches) OD, with 1.7-mm (0.065-inch) wall thickness, were slipped over the ends and bolted.

final comments

Putting up an array of this size in a small working area requires a lot of patience and the desire to succeed. My residential lot is only 20 meters (66 feet) wide by 31 meters (100 feet) long. Anyone who has attempted such a task will tell you that quad wires actually look for something in which to get tangled. Also, no matter how carefully you walk across a lawn full of strung spreaders you'll inevitably trip on some of the wires. Finally, my roof is made of thick shingles. No self-respecting wire would dare pass one up without trying to slide underneath.

I'm now in the process of tuning this monster, so I have no final words on performance. But it had better be great! Once tuned up, it'll be elevated to 22.3 meters (73 feet), where I hope to terrorize the ham bands — at least until the first big windstorm.

ham radio

More Details? CHECK—OFF Page 94

7400 TTL

		SN7470N	.29		
		SN7472N	.29		
SN7400N	.20	SN7473N	.35	SN74160N	.89
SN7401N	.20	SN7474N	.35	SN74161N	.89
SN7402N	.20	SN7475N	.49	SN74162N	1.95
SN7403N	.20	SN7476N	.35	SN74163N	.89
SN7404N	.25	SN7479N	5.00	SN74164N	.89
SN7405N	.20	SN7480N	.50	SN74165N	.89
SN7406N	.29	SN7482N	.99	SN74166N	1.25
SN7407N	.29	SN7483N	.69	SN74167N	1.95
SN7408N	.20	SN7485N	.89	SN74170N	1.59
SN7409N	.20	SN7486N	.35	SN74172N	6.00
SN7410N	.18	SN7489N	1.75	SN74173N	1.25
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SN7412N	.25	SN7491N	.59	SN74175N	1.00
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SN7417N	.25	SN7495N	.65	SN74180N	.79
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SN7432N	.25	SN74125N	.49	SN74193N	.79
SN7437N	.25	SN74126N	.49	SN74194N	.89
SN7438N	.40	SN74132N	.75	SN74195N	.69
SN7439N	.25	SN74136N	.75	SN74196N	.89
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SN7444N	.75	SN74145N	.79	SN74251N	.99
SN7445N	.75	SN74147N	1.95	SN74279N	.79
SN7446N	.69	SN74148N	1.29	SN74283N	2.25
SN7447N	.59	SN74150N	1.25	SN74284N	3.95
SN7448N	.79	SN74151N	.59	SN74285N	3.95
SN7450N	.20	SN74152N	.59	SN74365N	.69
SN7451N	.20	SN74153N	.59	SN74366N	.69
SN7453N	.20	SN74154N	1.50	SN74367N	.69
SN7454N	.20	SN74155N	.79	SN74368N	.69
SN7459A	.25	SN74156N	.79	SN74390N	1.95
SN7460N	.20	SN74157N	.65	SN74393N	1.95

CMOS

CD4000	.39			CD4070	.55
CD4001	.39			CD4071	.49
CD4002	.39	CD4028	.89	CD4072	.49
CD4006	1.19	CD4029	1.49	CD4076	1.39
CD4007	.25	CD4030	.49	CD4081	.39
CD4009	.49	CD4035	.99	CD4082	.39
CD4010	.49	CD4040	1.49	CD4093	.99
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CD4013	.49	CD4043	.89	MC14410	14.95
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CD4020	1.19	CD4051	1.19	MC14583	2.49
CD4021	1.39	CD4053	1.19	CD4508	3.95
CD4022	1.19	CD4056	2.95	CD4510	1.39
CD4023	.29	CD4059	9.95	CD4511	1.29
CD4024	.79	CD4060	1.49	CD4515	2.95
CD4025	.23	CD4066	.79	CD4518	1.29
CD4026	2.95	CD4068	.39	CD4520	1.29
CD4027	.69	CD4069	.45	CD4566	2.25

74C00

74C00	.39			74C163	2.49
74C02	.39			74C164	2.49
74C04	.45	74C85	2.49	74C173	2.60
74C08	.49	74C90	1.95	74C192	2.49
74C10	.39	74C93	1.95	74C193	2.49
74C14	1.95	74C95	1.95	74C195	2.49
74C20	.39	74C107	1.25	74C922	7.95
74C30	.39	74C151	2.90	74C923	6.25
74C42	1.95	74C154	3.00	74C925	8.95
74C48	2.49	74C157	2.15	74C926	8.95
74C73	.89	74C160	2.49	80C95	1.50
74C74	.89	74C161	2.49	80C97	1.50

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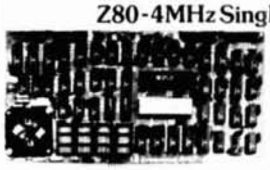
LM301CN/H	.35	LM340K-18	1.35	LM733N	1.00
LM302H	.75	LM340K-24	1.35	LM739N	1.19
LM304H	1.00	LM340T-5	1.25	LM741CN/H	.35
LM305H	.60	LM340T-6	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-8	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-12	1.25	LM748N/H	.39
LM309H	1.10	LM340T-15	1.25	LM1310N	1.95
LM309K	1.25	LM340T-18	1.25	LM1458CN/H	.59
LM310CN	1.95	LM340T-24	1.25	MC1488N	1.95
LM311N/H	.90	LM358N	1.00	MC1489N	1.95
LM312H	1.95	LM370N	1.95	LM1496N	.95
LM317K	6.50	LM373N	3.25	LM1556V	1.75
LM318CN/H	1.50	LM377N	4.00	MC1741SCP	3.00
LM319N	1.30	LM380N	1.25	LM2111N	1.95
LM320K-5	1.35	LM380CN	.99	LM2901N	2.95
LM320K-5.2	1.35	LM381N	1.79	LM3053N	1.50
LM320K-12	1.25	LM382N	1.79	LM3065N	1.49
LM320K-15	1.35	NE501N	8.00	LM3900N(3401)	.59
LM320K-18	1.35	NE510A	6.00	LM3905N	1.49
LM320K-24	1.35	NE529A	4.95	LM3909N	1.25
LM320T-5	1.25	NE531H/V	3.95	MC5558V	.59
LM320T-5.2	1.25	NE536T	6.00	8038B	4.95
LM320T-8	1.25	NE540	6.00	LM75450N	.49
LM320T-12	1.25	NE544N	4.95	75451CN	.39
LM320T-15	1.25	NE550N	1.30	75452CN	.39
LM320T-18	1.25	NE555V	.39	75453CN	.39
LM320T-24	1.25	NE556N	.99	75454CN	.39
LM323K-5	5.95	NE560B	5.00	75491CN	.79
LM324N	1.49	NE562B	5.00	75492CN	.89
LM339N	.99	NE565N/H	1.25	75493N	.89
LM340K-5	1.35	NE566CN	1.75	75494CN	.89
LM340K-6	1.35	NE567V/H	.99	RC4136	1.25
LM340K-8	1.35	NE570N	4.95	RC4151	3.95
LM340K-12	1.35	LM703CN/H	.69	RC4194	4.95
LM340K-15	1.35	LM709N/H	.29	RC4195	4.49

74LS00TTL

74LS00	.35			74LS139	1.05
74LS01	.35	74LS51	.29	74LS151	1.05
74LS02	.35	74LS54	.29	74LS155	1.05
74LS03	.35	74LS55	.29	74LS157	1.05
74LS04	.42	74LS73	.54	74LS160	1.15
74LS05	.42	74LS74	.54	74LS161	1.39
74LS08	.35	74LS75	.71	74LS162	1.25
74LS09	.42	74LS76	.54	74LS163	1.39
74LS10	.35	74LS78	.49	74LS164	1.50
74LS11	.75	74LS83	1.05	74LS175	1.25
74LS13	.59	74LS85	1.50	74LS181	2.49
74LS14	1.25	74LS86	.54	74LS190	1.39
74LS15	.35	74LS90	.71	74LS191	1.39
74LS20	.35	74LS92	.90	74LS192	1.39
74LS21	.35	74LS93	.90	74LS193	1.39
74LS22	.35	74LS95	.99	74LS194	1.39
74LS26	.35	74LS96	1.15	74LS195	1.39
74LS27	.35	74LS107	.54	74LS253	1.25
74LS28	.35	74LS109	.54	74LS257	1.05
74LS30	.35	74LS112	.54	74LS258	1.75
74LS32	.42	74LS123	1.50	74LS260	.83
74LS37	.45	74LS125	1.05	74LS279	.90
74LS40	.35	74LS132	.99	74LS367	.75
74LS42	1.09	74LS136	.59	74LS368	.75
74LS47	1.05	74LS138	1.05	74LS670	2.49

Cromemco
Incorporated

Z80-4MHz Single Card Computer



Cromemco's Single Card Computer is a complete computer which brings the power of the Z-80 and the flexibility of the S-100 bus to the dedicated computer environment.

The card offers 4 MHz operation, 8K bytes of on-board 2716 PROM, and 1K byte of static RAM memory. This stand-alone card also provides an RS-232 (or 20mA current loop) serial interface with programmable baud rates to 76,800, vectored interrupts, 24 bits of bidirectional parallel I/O, and 5 programmable timers. Only a power supply and PROM software are required for operation. The Single Card Computer is assembled and tested (Model SCC-W) for $450. The Monitor and Control BASIC are available in two ROM's (Model MCB-216) for $95.

SCC-W (Assembled) **$450.00**

DISCRETE LEDS

XC556R	.200"	red	5/$1	MV50	.085"	red	6/$1	XC111R	.190"	red	5/$1
XC556G	.200"	green	4/$1	XC209R	.125"	red	5/$1	XC111G	.190"	green	4/$1
XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1	XC111Y	.190"	yellow	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1	XC111C	.190"	clear	4/$1
XC22R	.200"	red	5/$1	XC526R	.185"	red	5/$1				
XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1				
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1	INFRA-RED LED			
MV10B	.170"	red	4/$1	XC526C	.185"	clear	4/$1	¼"x¼"x1/16" flat			5/$1

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	3.25	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	1.25	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

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MM5725	$2.95
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DM8864	2.00
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DM8887	.75
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9374 7-seg. LED driver	1.50
MM5309	4.95

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MM5309	4.95
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MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
CT 7001	6.95

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MC1408L8	5.75
MC1439L	2.95
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MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.39	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

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ASST. 3	5 ea	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	50 PCS	1.75
ASST. 4	5 ea	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	50 PCS	1.75
ASST. 5	5 ea	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	50 PCS	1.75
ASST. 6	5 ea	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	50 PCS	1.75
ASST. 7	5 ea	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	50 PCS	1.75

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DS0026CH	5Mhz 2-phase MOS clock driver	3.75
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MM5320	TV Camera Sync. Generator	14.95
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XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	.28
1N965	15	400m	4/1.00	1N4734	5.6	1w	.28
1N5232	5.6	500m	.28	1N4735	6.2	1w	.28
1N5234	6.2	500m	.28	1N4736	6.8	1w	.28
1N5235	6.8	500m	.28	1N4738	8.2	1w	.28
1N5236	7.5	500m	.28	1N4742	12	1w	.28
1N5242	12	500m	.28	1N4744	15	1w	.28
1N5245	15	500m	.28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
		2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
.1/35V	.39	.31	.25	1.5/35V	.41	.33	.26
.15/35V	.39	.31	.25	2.2/35V	.51	.41	.33
.22/35V	.39	.31	.25	3.3/25V	.53	.43	.34
.33/35V	.39	.31	.25	4.7/25V	.63	.51	.41
.47/35V	.39	.31	.25	6.8/25V	.79	.63	.50
.68/35V	.39	.31	.25	15/25V	1.39	1.12	.89
1.0/35V	.39	.31	.25	22/6V	.79	.63	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead	1-9	10-99	100-	Radial Lead	1-9	10-99	100-
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

earth anchors
for guyed towers

Design data
for earth anchors
and how to make
a deadman anchor
for your tower guys

Often the design of a guyed tower fails to include the anchor design. This article describes construction and implementation of guy anchors.

holding power

The holding power of an anchor depends on anchor size and its depth in the ground. The weight of the earth above the anchor provides the holding force. Standard practice is to figure the holding force of earth in a cone shape above the anchor with a slope of 30 degrees relative to the vertical, as shown in **fig. 1**.

Note that, if the actual anchor were cone shaped, the total cone size would depend on depth, D. The cone volume, V, is:

$$V = 1/3\, \pi R^2 D \tag{1}$$

Radius, R, is proportional to depth, D, where

$$R = D \tan 30\ degrees = D(0.577)$$

Therefore:

$$V = 1/3\, \pi\, (0.577D)^2\, D \cong 0.35D^3$$

If the weight, W, of earth is assumed to be 100 pounds/foot^3 (45 kg/0.3 meter^3), and the holding force, $F, = VW$, then $F = 35D^3$. Holding force versus anchor depth is shown in **fig. 2**.

If you use 1/4-inch (6.5-mm) diameter steel cable for guy wire, the breaking strength is 5480 pounds (2488 kg). An anchor for this cable buried 5-1/2 feet (1.7 meters) would be appropriate.

table 1. Holding force at depths of 1-6 feet (0.3-1.8 meters).

depth		holding force	
feet	(meters)	pounds	(kg)
0		0	
1	(0.3)	35	(16)
2	(0.6)	280	(127)
3	(0.9)	945	(429)
4	(1.2)	2240	(1017)
5	(1.5)	4375	(1986)
6	(1.8)	7560	(3432)

By Ted Hart, W5QJR, Box 334, Melbourne, Florida 32901

deadman anchors

Screw anchors, available from lumber yards and marine-supply houses, have been used for antenna

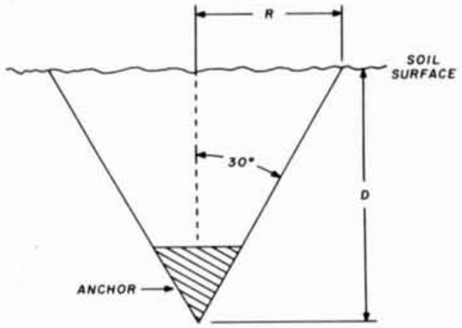


fig. 1. The holding power of an anchor depends on anchor size and depth in the ground. Weight of earth above the anchor provides the holding force. Standard practice for such anchors is to figure the holding force of the earth in a cone with a slope of 30 degrees.

guys but they're expensive. So I decided to make a deadman anchor from concrete. Here's how to do it:

1. Make a loop of your guy wire and tie it with a cable clamp.

2. Pass two pieces of concrete reinforcing rod, 5 inches (128 mm) long through the loop and tie the rods at right angles. Use heavy wire to make the connection.

3. Use a container, such as a plastic pail, to pot the assembly in concrete.

Holes for the deadman anchors can be made with a post-hole digger. Make sure the dirt is moist. Tamp

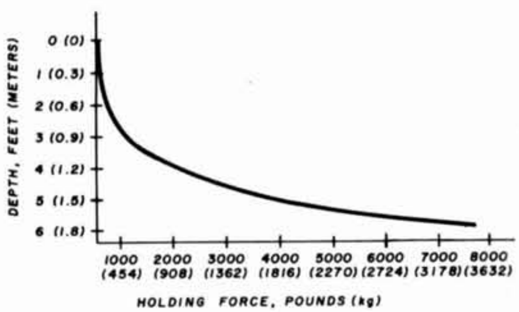
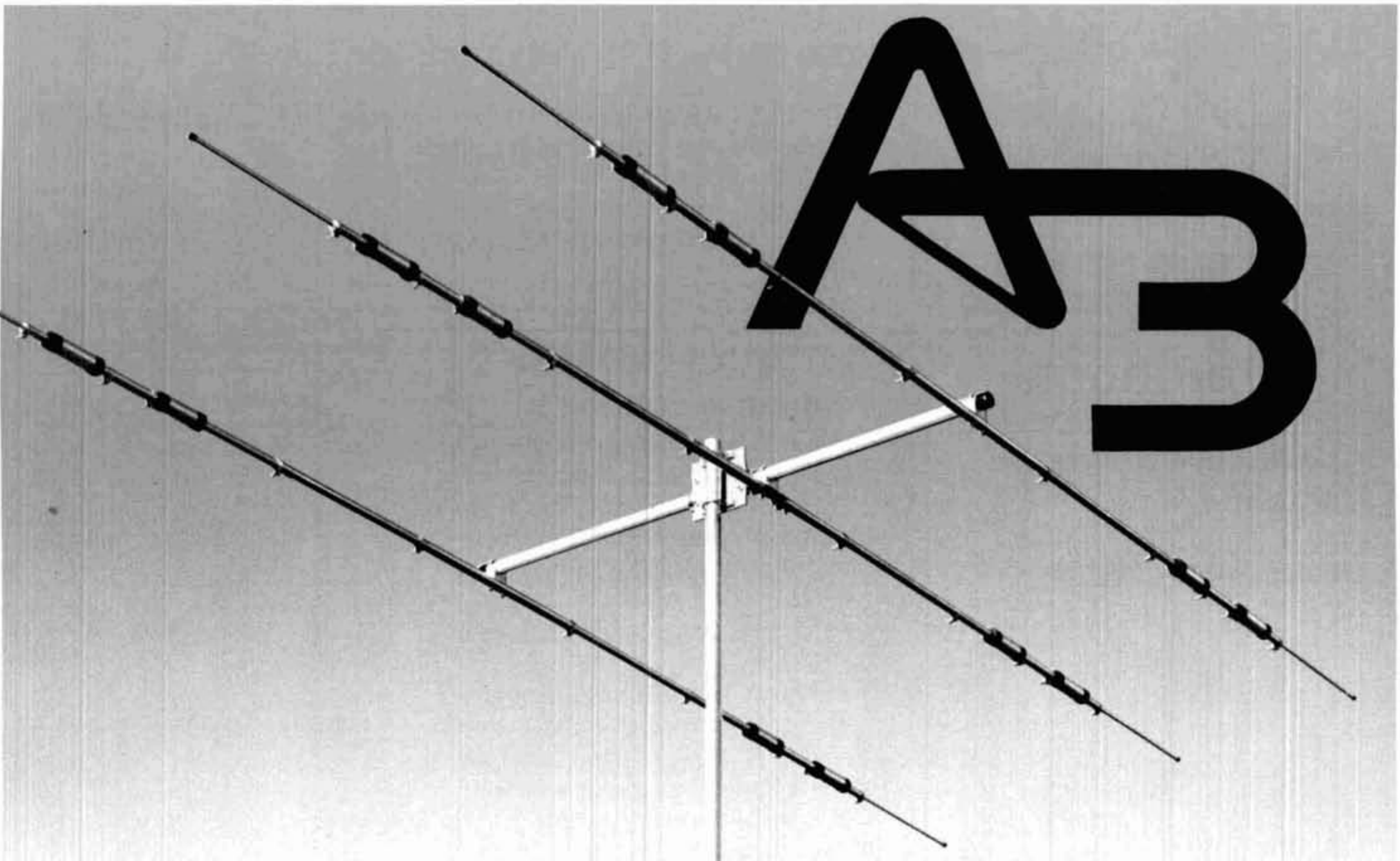


fig. 2. A plot of holding force as a function of depth for anchors buried in earth.

the dirt and wait a few days for the earth to settle. You'll have to tighten the guy wires several times during the first few days after installation while the cable aligns itself through the earth.

ham radio

More Details? CHECK—OFF Page 94



$199.95

Forward Gain	8 dBd
Front to back ratio avg.	25 dB
V.S.W.R.	1.2-1 Typical
Average Bandwidth	500 KHz
Power Rating	2000 w PEP
Feed Point Impedance	50 Ω
Connector	Twin terminal stainless steel takes all coax.
Boom	1⅝"-1½" x 14'
Elements/Longest	1⅛"-½" x 27'9"
Wind Sfc. area	5.6 Feet²
Weight	35 Pounds
Turn Radius	15'6"
Mast Diameter	1¼" min. 2" max.
Material	6063-T832 Seamless aluminum
Fasteners	Zinc Plated Steel
Telescope Method	Taper tubing with full circle clamps

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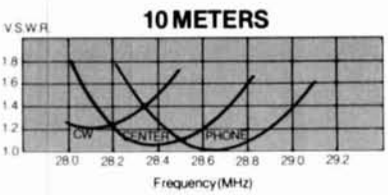
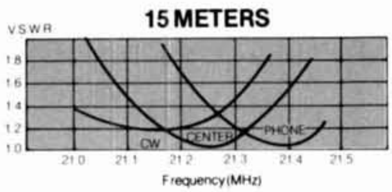
The full power, full performance 20-15-10 meter beam.

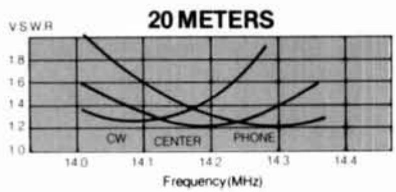
Enjoy the thrill of working rare DX with excellent A3 forward gain. Increase the pleasure of your daily contacts with A3 interference reducing front to back ratio. Use your linear amplifier with confidence in our new A3 high power traps.

Make friends of your neighbors with A3 compact dimensions, low profile, and small turn radius. Satisfy your budget with A3 economy pricing.

The Cushcraft engineering team has again created that unique combination of quality materials, easy assembly and high performance with A3, the three band beam for the eighties.







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CORPORATION

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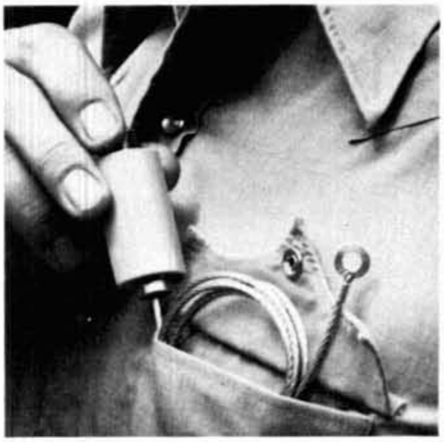
NEW products

portable emergency antenna



Larsen Electronics, Inc., has a portable emergency antenna that requires no ground plane and is compact enough to fit into your pocket. The PHW-150 loaded half-wave antenna covers the 144-174 MHz band. It features a stainless-steel flexible radiator that allows the PHW-150 to be rolled up into a convenient portable size.

To operate the PHW, simply connect it to a portable radio with any length of coaxial cable, attach a length of fishing line to the antenna eyelet and a weight to the other end of the line, then heave the weight over a tree limb and hoist the PHW-150 into the air with the fishing line.

Having Larsen's PHW-150 is like having a base antenna and tower in one compact, portable unit. The PHW-150 can provide as much as 20 dB gain when compared with a portable radio's normal antenna.

The PHW-150 comes without fishline, weight and coaxial cable. For more information, write John Beaman, Larsen Electronics, Inc., P.O. Box 1686, Vancouver, Washington 98663.

DSI 50 Hz to 550 MHz frequency counter

A new 50-Hz to 550-MHz nine-digit frequency counter is available from DSI Instruments, Inc. The model 5600A combines a 10-MHz proportional-oven time-base accuracy of 0.2 ppm (from 10° C to 40° C) with a 10-mW sensitivity and resolutions to 0.1 Hz.

Its bright 0.5-inch-high nine-digit LED array — with automatic zero blanking — provides enhanced readability at a distance and at wide viewing angles, even in bright light.

Two input channels are provided: one covering the 50-Hz to 500-MHz range, the other covering 50 MHz to 550 MHz. High-visibility indicator lights for "Standby," "Oven-Ready," and "Gate-Time" status are standard features. The user can select a desired resolution from 0.1 Hz to 1.0 kHz by push-button. Additional features include an rf preamplifier and a 500-MHz prescaler.

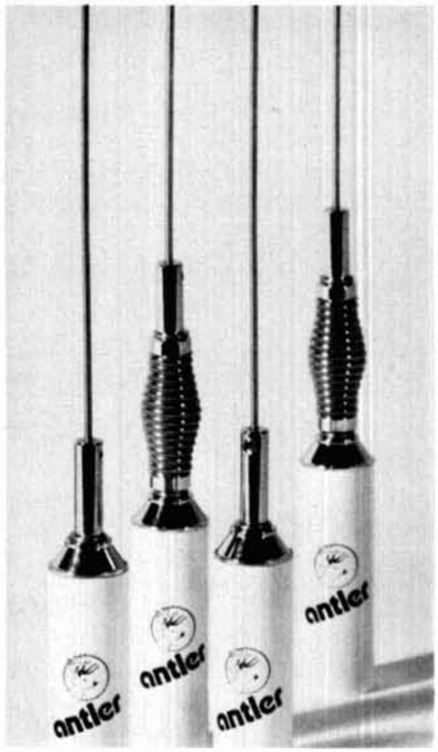
Housed in an impact-resistant, molded cabinet with a multi-position carrying handle-easel, the 5600A operates directly on an internal 8.2 to 14.5 Vdc battery or a 115-Vac adaptor. It measures 3.25 × 9.5 × 9 inches, including a self-contained battery compartment.

Options include a 10-hour rechargeable battery pack, an audio multiplier that allows up to 0.001-Hz resolution, and a 25-dB preamplifier with a variable sensitivity control.

The 5600A is available in two forms: a kit, 95 per cent factory-assembled, for $149.95, and factory assembled for $179.95.

For more information contact DSI Instruments, Inc., 9550 Chesapeake Drive, San Diego, California 92123.

new "Pro" antenna line



Users of two-way radio communications are welcoming the announcement of a new "Professional" line of Antler Antennas. The new Antler "Pro" antennas include four basic base-loaded models spanning from 30-174 MHz frequencies, plus a "short" quarter-wave, roof-mounted unit tuned to resonate on frequencies between 108 and 174 MHz.

The Professional Antler antennas feature individual testing, and precision electronic tuning of each base coil to ensure efficient, dependable transmissions. The four base-loaded models are for frequencies from 30-36, 36-42, 45-50, and 130-174 MHz. Each antenna is provided with an accurate cutting chart to pinpoint desired frequencies. All coil fittings are precision-machined of chrome-plated, solid brass.

A popular feature of the new Antler line is the buyer's flexibility to order the exact equipment he needs. There are three mounts, including a "no-hole" trunk-lip mount complete with an attractive, chrome-plated dress cup which hides the attaching clamp. A roof or cowl mount with an easy-to-install snap-in expansion collet is also available, along with Antler's proved "Posi-grip" magnetic mount. Stainless steel shock springs are also available where desired. All mountings include factory-made, low-loss coax cable assemblies.

A handy, short, quarter-wave roof-mount model is also available where "in-city" use encounters low-clearance problems of parking garages and overhanging obstructions.

The Antler "Pro" line is distributed nationally through electronic distributors and two-way or Amateur Radio dealers. For more information, address Antler Antennas, 6200 South Freeway, Fort Worth, Texas 76134.

Antenna Specialists low-cost Yagi

Exceptional performance at moderate cost were the key design requirements for a new uhf Yagi antenna, model ASP-766, announced by The Antenna Specialists Co., Cleveland, Ohio. The five-element beam antenna is applicable to both point-to-point or repeater-control station installations, where large gain values are secondary in importance to reliability. Directivity necessary to repeater control stations is ensured by the antenna's 15-dB front-to-back ratio. The antenna is designed to provide 50 degree E-plane beamwidth for appropriate azimuthal selectivity in crowded rf environments. Construction is of aluminum, with gold iridite for both appearance and resistance to pitting and corrosion. The ASP-766 is a broadband antenna covering the 450-470 MHz range, exhibiting 7.5 dB gain in conformity with EIA specification RS-329. Maximum rf power rating is 100 watts. For detailed product information, write to Professional Products Division, The Antenna Specialists Co., 12435 Euclid Avenue, Cleveland, Ohio 44106.

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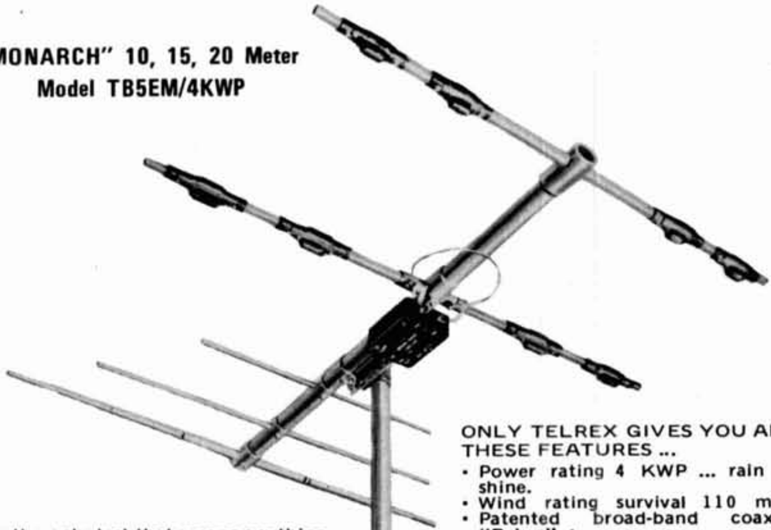
Professionally Engineered Antenna Systems

Single transmission line **"TRI-BAND® ARRAY"**

"MONARCH" 10, 15, 20 Meter
Model TB5EM/4KWP

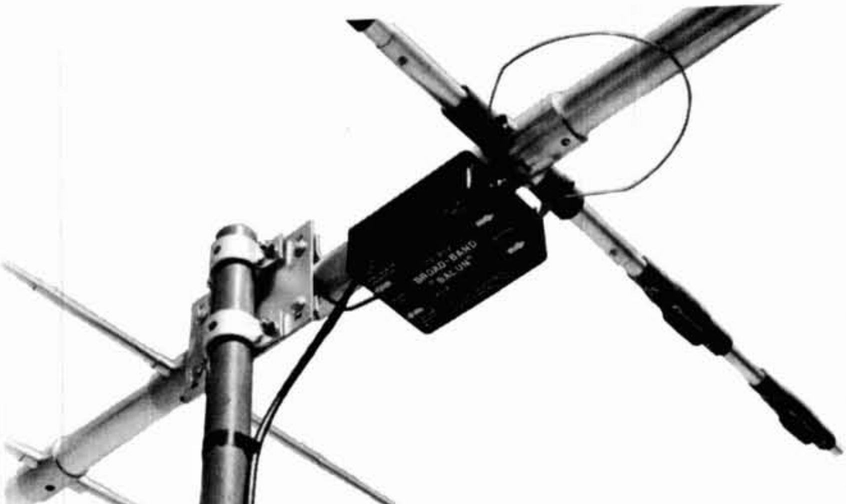


By the only test that means anything ... on the air comparison ... this array continues to outperform all competition ... and has for two decades. Here's why ... Telrex uses a unique trap design employing 20 HiQ 7500 V ceramic condensers per antenna. Telrex uses 3 optimum-spaced, optimum-tuned reflectors to provide maximum gain and true F/B Tri-Band performance.

ONLY TELREX GIVES YOU ALL THESE FEATURES ...

- Power rating 4 KWP ... rain or shine.
- Wind rating survival 110 mph
- Patented broad-band coaxial "Balun"
- Heavy-duty steel gusset mounting plate.
- Aluminum boom 2", 2-1/2" O.D. x 18 ft.
- Large diameter, .058 wall taper-swaged dural elements for minimum weight and exceptional strength to weight ratio.
- Stainless steel electrical hardware.

At 50 ft. or more (above ground) a rugged Telrex "Tri-Band" is the only answer to longevity ... a true money saver.



Illustrated: Rugged gusset mounting plate, Broad-Band - non ferrite - "Balun", and Driven Element center section.

For technical data and prices on complete Telrex line, write for Catalog PL-7.

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SYNTHESIZER KITS from 50 to 450 MHz. Prices start at $119.95.

Now available in KIT FORM — GLB Model 200 MINI-SIZER.

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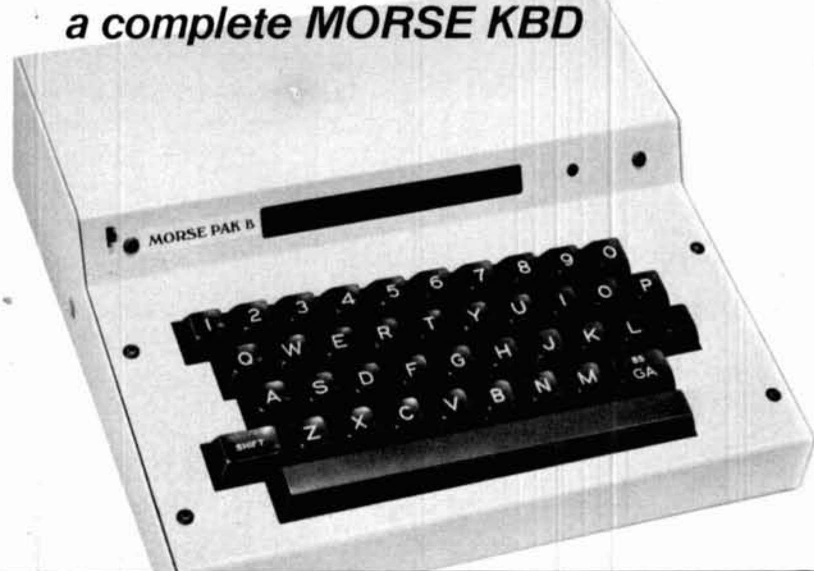
MORSE PAK-B $350.00

with all the receive features of MORSE PAK-A, it also is a complete MORSE KBD



Features include:

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	125	250	400	500	600	800	1.8	2.1	2.4	6.0	8.0
YAESU	$55 EACH										
*FT-101/F/FR-101		✓		✓	✓		✓		✓	✓	
*FT-301/FT-7B/620		✓		✓			✓		✓	✓	
*FT-901/101ZD/107		✓		✓			✓			✓	
FT-401/560/570		✓		✓			✓	✓			
FT-200/TEMPO I							✓	✓			
KENWOOD	$55 EACH										
*TS-520/R-599		✓	✓				✓		• 2nd IF $125		
*TS-820/R-820		✓	✓				✓	●	for R-820 only		
HEATH	$55 EACH										
ALL HF		✓	✓				✓	✓			
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R-4C	GUF-1 Broad 1st IF Superior Shape Factor/Ult Rej $65									✓	✓
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75S-3B/C		✓	EQUALS OR EXCELS $400 COLLINS UNIT								

***DIODE SWITCHING BOARDS** available to permit 1, 2 or more filters than those for which manufacturer provides room. **SPECIFY** make and model.

Single-filter type: $12 Airmail postpaid
Dual-filter type: $21 Airmail postpaid

Florida residents add 4% (sales tax) (FOREIGN ADD $3 per filter)

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Dealer Inquiries Welcomed

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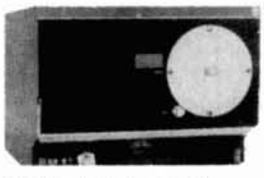
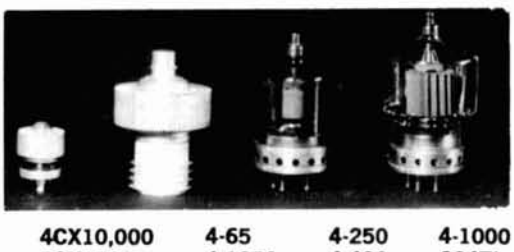


490-T Ant. Tuning Unit
(Also known as CU1658 and CU1669)

618-T Transceiver
(Also known as MRC95, ARC94, ARC102, or VC102)



4CX150
4CX250
4CX300A
4CX350A
4CX1000
4CX1500
4CX3000
4CX5000

4CX10,000	**4-65**	**4-250**	**4-1000**
5CX1500	**4-125A**	**4-400**	**304TL**

Other tubes and Klystrons also wanted.

Highest price paid for these units. Parts purchased. Phone **Ted, W2KUW collect.** We will trade for new amateur gear. GRC106, ARC105, ARC112, ARC114, ARC115, ARC116, and some aircraft units also required.

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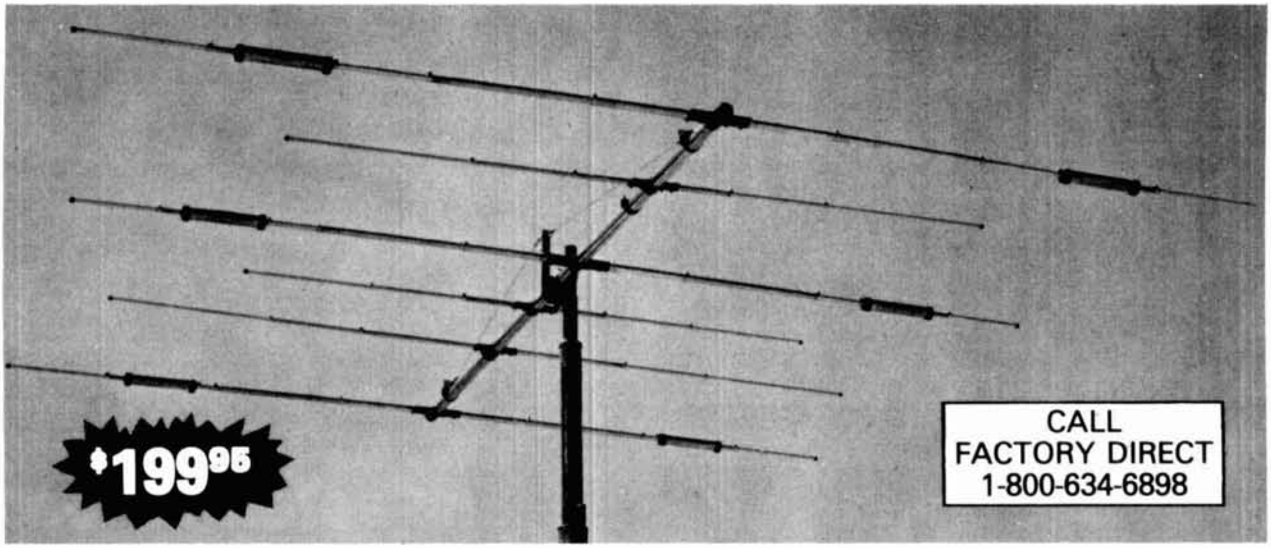
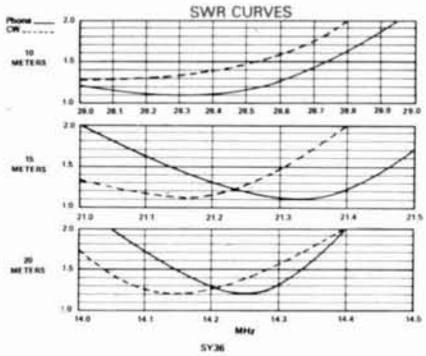
WILSON SYSTEMS, INC.

the SYSTEM 36



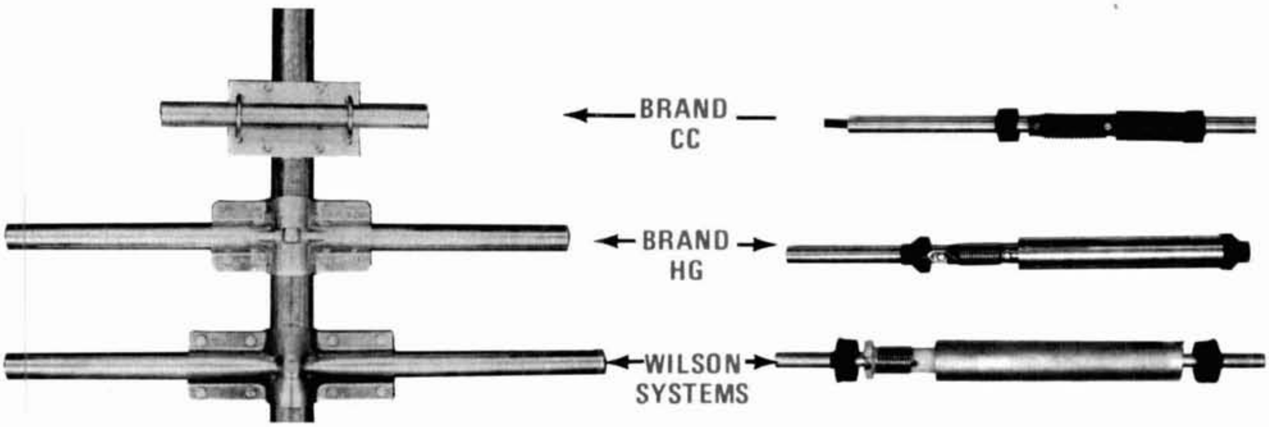
A trap loaded antenna that performs like a monobander! That's the characteristic of this six element three band beam. Through the use of wide spacing and interlacing of elements, the following is possible: three active elements on 20, three active elements on 15, and four active elements on 10 meters. No need to run separate coax feed lines for each band, as the bandswitching is automatically made via the High-Q Wilson traps. Designed to handle the maximum legal power, the traps are capped at each end to provide a weather-proof seal against rain and dust. The special High-Q traps are the strongest available in the industry today.



SPECIFICATIONS

Band MGz	14-21-28
Maximum power input	Legal Limit
Gain (dBd)	9 db
VSWR @ resonance	1.3:1
Impedance	50 ohm
F/B Ratio	20 db or Better
Boom (O.D. x Length)	2" x 24'2½"
No. of Elements	6
Longest Element	28'2½"
Turning Radius	18'6"
Maximum Mast Diameter	2"
Surface Area	8.6 sq. ft.
Matching Method	Beta
Wind Loading @ 80 mph	215 lbs.
Maximum Wind Survival	100 mph
Feed Method	Coaxial Balun (supplied)
Assembled Weight (approx.)	53 lbs.
Shipping Weight (approx.)	62 lbs.

Compare the SY-36 with others . . .



Compare the size and strength of the boom to element clamps. See who offers the largest and heaviest duty. Which would you prefer?

Wilson Systems traps offer a larger diameter trap coil and a larger outside housing, giving excellent Q and power capabilities.

CALL
FACTORY DIRECT
1-800-634-6898

WSI WILSON SYSTEMS, INC.
4286 S. Polaris Ave., Las Vegas, Nevada 89103

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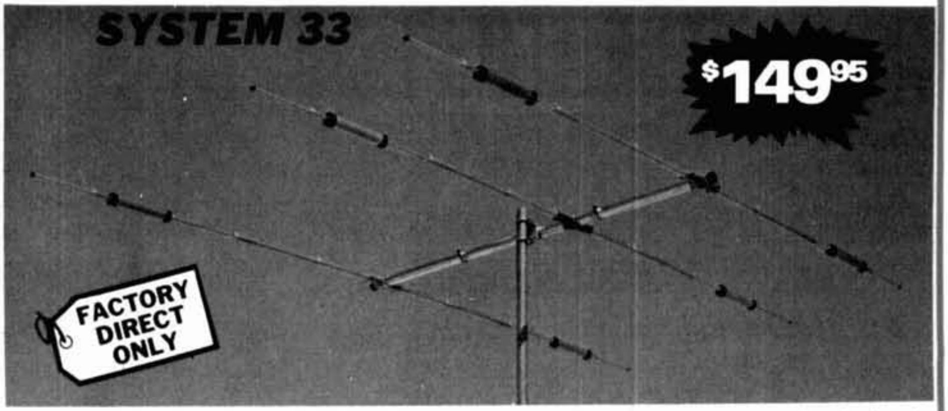
WILSON SYSTEMS INC.



Capable of handling the Legal Limit, the *SYSTEM 33* is the finest compact tri-bander available to the amateur.

Designed and produced by one of the world's largest antenna manufacturers, the traditional quality of workmanship and materials excells with the *SYSTEM 33.*

New boom-to-element mount consists of two 1/8" thick formed aluminum plates that will provide more clamping and holding strength to prevent element misalignment.

Superior clamping power is obtained with the use of a rugged 1/4" thick aluminum plate for boom to mast mounting.

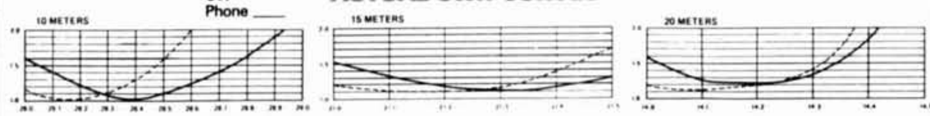
The use of large diameter High-Q Traps in the *SYSTEM 33* makes it a high performing tri-bander and at a very economical price.

A complete step-by-step illustrated instruction manual guides you to easy assembly and the lightweight antenna makes installation of the *SYSTEM 33* quick and simple.

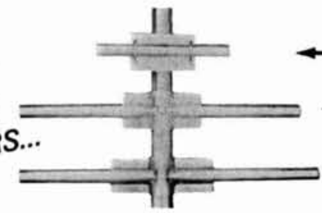
SPECIFICATIONS

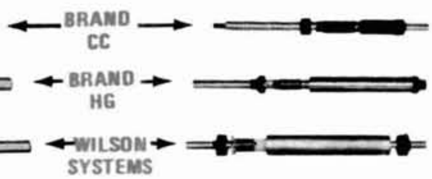
Band MHz..........14-21-28	Boom (O.D. x length)2" x 14'4"	Wind load @ 80 mph .. 114 lbs
Max. power input...Legal limit	No. elements............ 3	Assembled Wt......... 37 lbs
Gain (dbd).........Up to 8 dB	Longest element........27'4"	Shipping Wt........... 42 lbs
VSWR at resonance.....1.3:1	Turning radius.........15'9"	Direct 52 ohm feed
Impedence..........50 ohms	Max. mast diameter...2" O.D.	no balun required
F/B ratio.......20 dB or better	Surface area........5.7 sq. ft.	Max wind survival ... 100 mph

ACTUAL SWR CURVES



COMPARE THE SY33 WITH OTHERS...





Compare the size and strength of the boom to element clamps. See who offers the largest and heaviest duty. Which would you prefer?

Wilson Systems traps offer a larger diameter trap coil and a larger outside housing, giving excellent Q and power capabilities.

NEW! ADD 40 METERS TO YOUR TRI-BAND WITH THE NEW 33-6 MK

$49^95

— IN STOCK —

Now you can have the capabilities of 40-meter operation on the *SYSTEM 36* and *SYSTEM 33.* Using the same type high quality traps, the 40-meter addition will offer 200 KHZ of bandwidth at less than 2:1 SWR. The new 33-6 MK will fit your present SY36, SY33, or SY3 and use the same single feed line.

The 33-6 MK adds approximately 20' to the driven element of your tri-bander, increasing the tuning radius by 5 to 6 feet. This addition will offer an effective rotatable dipole at the same height of your beam. The 33-6 MK will not interfere with the operation of 10, 15 or 20 mtrs.

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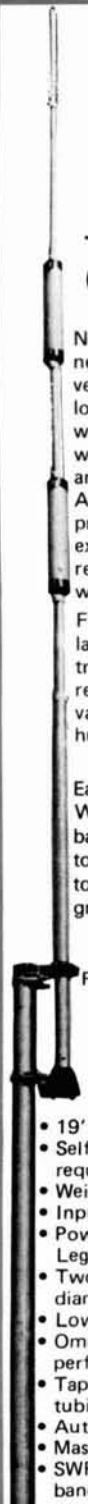

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WV-1A

4 BAND TRAP VERTICAL (10 - 40 METERS)

No bandswitching necessary with this vertical. An excellent low cost DX antenna with an electrical quarter wavelength on each band and low angle radiation. Advanced design provides low SWR and exceptionally flat response across the full width of each band.

Featured is the Wilson large diameter High-Q traps which will maintain resonant points with varying temperatures and humidity.

Easily assembled, the WV-1A is supplied with a base mount bracket to attach to vent pipe or to a mast driven in the ground.

Note:
Radials are required for peak operation.
(See GR-1 below)

SPECIFICATIONS

- 19' total height
- Self supporting — no guys required
- Weight — 14 lbs.
- Input impedance: 50 Ω
- Powerhandling capability: Legal Limit
- Two High-Q traps with large diameter coils
- Low angle radiation
- Omnidirectional performance
- Taper swaged aluminum tubing
- Automatic bandswitching
- Mast bracket furnished
- SWR: 1.1:1 or less on all bands

GR-1

$12^95

The GR-1 is the complete ground radial kit for the WV-1A. It consists of: 150' of 7/14 stranded copper wire and heavy duty egg insulators, instructions. The GR-1 will increase the efficiency of the GR-1 by providing the correct counterpoise.

WILSON SYSTEMS TOWERS

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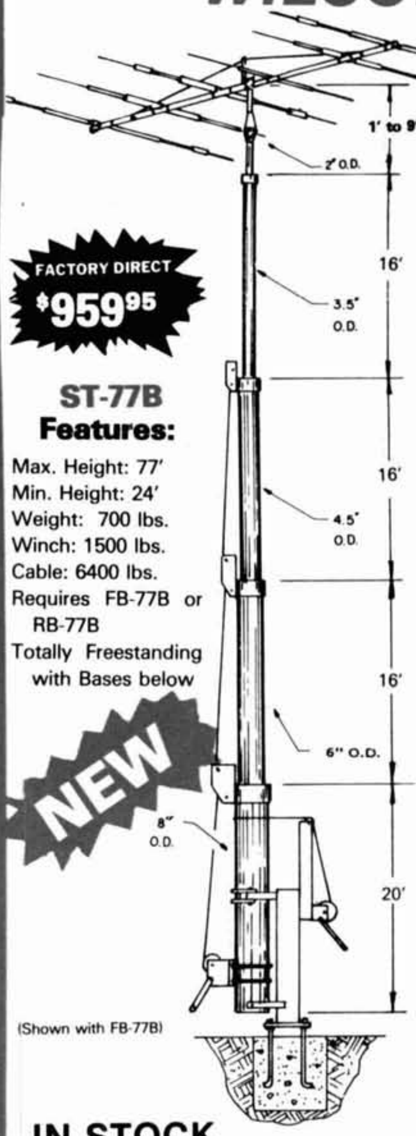

(Shown with FB-77B)

FACTORY DIRECT **$959.95**

NEW

ST-77B Features:

Max. Height: 77'
Min. Height: 24'
Weight: 700 lbs.
Winch: 1500 lbs.
Cable: 6400 lbs.
Requires FB-77B or RB-77B
Totally Freestanding with Bases below

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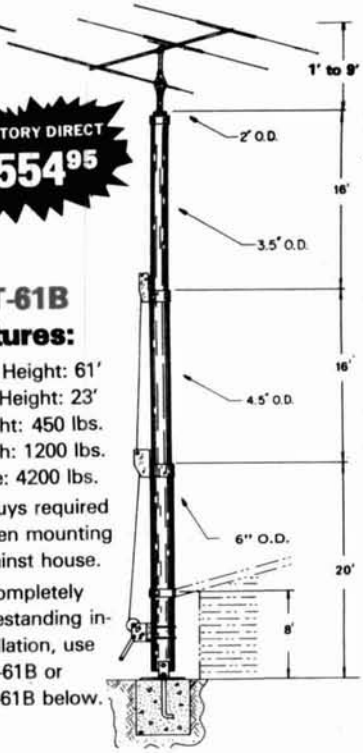
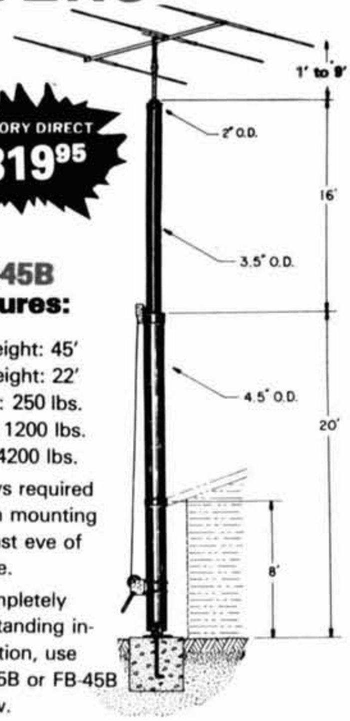


FACTORY DIRECT **$554.95**

MT-61B Features:

Max. Height: 61'
Min. Height: 23'
Weight: 450 lbs.
Winch: 1200 lbs.
Cable: 4200 lbs.
No Guys required when mounting against house.
For completely freestanding installation, use RB-61B or FB-61B below.



FACTORY DIRECT **$319.95**

TT-45B Features:

Max Height: 45'
Min. Height: 22'
Weight: 250 lbs.
Winch: 1200 lbs.
Cable: 4200 lbs.
No Guys required when mounting against eve of house.
For completely freestanding installation, use RG-45B or FB-45B below.

WIND LOADING

Tower	Height	Sq. Ft.	
ST-77B	69	18	Square Footage Based on 50 MPH Wind
	77	12	
MT-61B	53	18	
	61	12	
TT-45B	37	18	
	45	12	

BASE CHART

TOWER	WIDTH	DEPTH
TT-45B	12" x 12"	30"
FB-45B	30" x 30"	4½'
RB-45B	30" x 30"	4½'
MT-61B	18" x 18"	4'
FB-61B	3' x 3'	5½'
RB-61B	3' x 3'	5½'
ST-77B	See Below	Bases
FB-77B	3½' x 3½'	6'
RB-77B	3½' x 3½'	6'

Wilson Systems uses a new high strength carbon steel tube manufactured especially for Wilson Systems. It is 25% stronger than conventional pipe or tubing. The tubing size used is: 2" & 3½"-.095; 4½" & 6"-.125, 8"-.134. All tubing is hot dip galvanized. Top section is 2" O.D. for proper rotor and antenna mounting.

The TT-45B and MT-61B come complete with house bracket and hinged base plate for against-house mounting. For totally freestanding installation, use either of the tilt-over bases shown below.

The ST-77B can not be mounted against the house and must be used with the tilt-over base FB-77B or RB-77B shown below.

All three towers above are able to handle large arrays of up to 20 sq. ft. at 80 mph WHEN GUYED with one set of 4-point Guys at the top of the 3½" section. Guying Kits are available at the following prices: GK-45B – $59.95; GK-61B – $79.95; GK-77B – $99.95. When using the Guy System with RB Series Rotating Base, an additional thrust bearing at the top is required. The WTB-1 is available for $49.95.

TILT-OVER BASES FOR TOWERS

FIXED BASE

The FB Series was designed to provide an economical method of moving the tower away from the house. It will support the tower in a completely free-standing vertical position, while also having the capabilities of tilting the tower over to provide an easy access to the antenna. The rotor mounts at the top of the tower in the conventional manner, and will not rotate the complete tower.

FB-45B . . 112 lbs. . . $159.95
FB-61B . . 169 lbs. . . 219.95
FB-77B . . 250 lbs. . . 304.95

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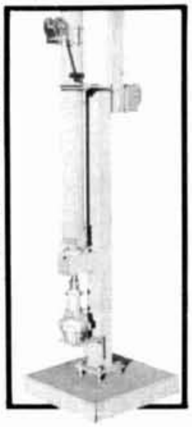
ROTATING BASE

The RB Series was designed for the Amateur who wants the added convenience of being able to work on the rotor from the ground position. This series of bases will give that ease plus rotate the complete tower and antenna system by the use of a heavy duty thrust bearing at the base of the tower mounting position, while still being able to tilt the tower over when desiring to make changes on the antenna system.

RB-45B . . 144 lbs. . . $224.95
RB-61B . . 229 lbs. . . 304.95
RB-77B . . 300 lbs. . . 454.95



Tilting the tower over is a one-man task with the Wilson bases. (Shown above is the RB-61B. Rotor is not included.)

WSI WILSON SYSTEMS, INC.
4286 S. Polaris Ave., Las Vegas, Nevada 89103

More Details? CHECK—OFF Page 94

WSI WILSON SYSTEMS, INC.
4286 So. Polaris Ave. • Las Vegas, Nevada 89103

TO: ALL AMATEURS
FROM: WILSON SYSTEMS, INC.

Two months ago we had the pleasure of introducing two new products—the 40 mtr add on kit and the ST-77 tower. This month we would like to introduce an exciting new antenna.

This is the antenna for the serious DX enthusiast . . . for the Ham who has decided to leave the average antenna alone and go for the best. If this describes you, or if you have been wanting monobanders for each of the 10, 15, and 20 mtr bands, but have held back due to the space or tower requirements to stack them — then wait no longer. Wilson Systems has the answer to the problem.

The "System 40" — a full monoband antenna for each band — on one boom and using only one feed line. It is broadbanded enough that a separate setting is not required for phone or cw operation. The parasitic elements are full size and with wide spacing so that there is no interaction between elements.

Extensive engineering and design has produced an antenna that offers all the advantages of separate stacked monobanders but with an added advantage of low cost. The price of the SY-40 is only $299.95. This price is possible only because we are factory direct to you, the amateur.

To introduce the SY-40, during the month of May we are offering a money-back guarantee. It is as simple as this: If you purchase the antenna during the month of May, 1980, you may try it out for thirty (30) days. At the end of that time, if you are not satisfied with its performance, return it for a full refund. That's how confident we are that you will like this antenna.

See the full page advertisement on the SY-40 elsewhere in this magazine. If you have any questions, please feel free to call on the toll free line (1-800-634-6898).

Yours truly,
JIM WILSON
Wilson Systems, Inc.

WILSON SYSTEMS, INC. — 4286 S. Polaris
Las Vegas, NV 89103 — (702) 739-7401

FACTORY DIRECT ORDER BLANK

Toll-Free Order Number
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WILSON SYSTEMS ANTENNAS

Qty	Model	Description	Shipping	Price
	SY40	10 Ele. Tribander for 10, 15, 20 Mtrs.	UPS	299.95
	SY36	6 Ele. Tribander for 10, 15, 20 Mtrs.	UPS	199.95
	SY33	3 Ele. Tribander for 1u, 15, 20 Mtrs.	UPS	149.95
	33-6 MK	40 Mtr. Mod Kit for SY33 & SY36	UPS	49.95
	WV-1A	Trap Vertical for 10, 15, 20, 40 Mtrs.	UPS	49.95
	GR-1	Ground Radials for WV-1A	UPS	12.95
	M-520A	5 Elements on 20 Mtrs.	TRUCK	229.95
	M-420A	4 Elements on 20 Mtrs.	UPS	159.95
	M-515A	5 Elements on 15 Mtrs.	UPS	129.95
	M-415A	4 Elements on 15 Mtrs.	UPS	84.95
	M-510A	5 Elements on 10 Mtrs.	UPS	84.95
	M-410A	4 Elements on 10 Mtrs.	UPS	69.95
		ACCESSORIES		
	T²X	Tail Twister Rotor	UPS	296.95
	HD-73	Alliance Heavy Duty Rotor	UPS	109.95
	RC-8C	8/C Rotor Cable	UPS	.12/ft.
	RG-8U	RG-8U Foam-Ultra Flexible Coaxial Cable. 38 strand center conductor, 11 guage	UPS	.21/ft.

NOTE:
On Coaxial and Rotor Cable, minimum order is 100' and 50' multiples.
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Ninety (90) Day Limited Warranty — All Products FOB Las Vegas, Nevada

WILSON SYSTEMS TOWERS

Qty.	Model	Description	Shipping	Price
	TT-45B	Freestanding 45' Tubular Tower	TRUCK	319.95
	RB-45B	Rotating Base for TT-45B w/tilt over feature	TRUCK	224.95
	FB-45B	Fixed Base for TT-45 B w/tilt over feature	TRUCK	159.95
	MT-61B	Freestanding 61' Tubular Tower	TRUCK	554.95
	RB-61B	Rotating Base for MT-61B w/tilt over feature	TRUCK	304.95
	FB-61B	Fixed Base for MT-61B w/tilt over feature	TRUCK	219.95
	ST-77B	Freestanding 77' Tubular Tower	TRUCK	959.95
	RB-77B	Rotating Base for ST-77B w/tilt over feature	TRUCK	454.95
	FB-77B	Fixed Base for ST-77B w/tilt over feature	TRUCK	304.95
	GK-45B	Guying Kit for TT-45B	UPS	59.95
	GK-61B	Guying Kit for MT-61B	UPS	79.95
	GK-77B	Guying Kit for ST-77B	UPS	99.95
	WTB-1	Thrust Bearing for Top of Tower	UPS	49.95

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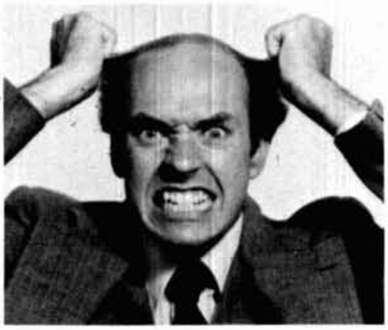
WHY ARE ANTENNA MAKERS ANGRY ABOUT THE NEW AEA ISOPOLE™?

Introductory Price:
Isopole 144—$49.95
Isopole 220—$44.95



For the first time, ham operators are finding out just how poorly designed most vertical, omnidirectional VHF antennas really are.

AEA university level research has proven that most antennas now being offered create unwanted coupling of RF currents onto the antenna support structure and coaxial feedline shield from the transceiver.

Proper design and decoupling on the new AEA ISOPOLE™ virtually eliminates the RF spillover problem and can help you achieve the maximum attainable gain for the size of the antenna—equivalent to doubling your power in all directions on the horizon relative to an ideal half-wave dipole, or 6 db gain over a typical one quarter wavelength groundplane antenna. The most popular 2 meter omnidirectional "gain" antennas are unable to achieve the gain figures for an ideal half-wave dipole, resulting from poor feedline decoupling.

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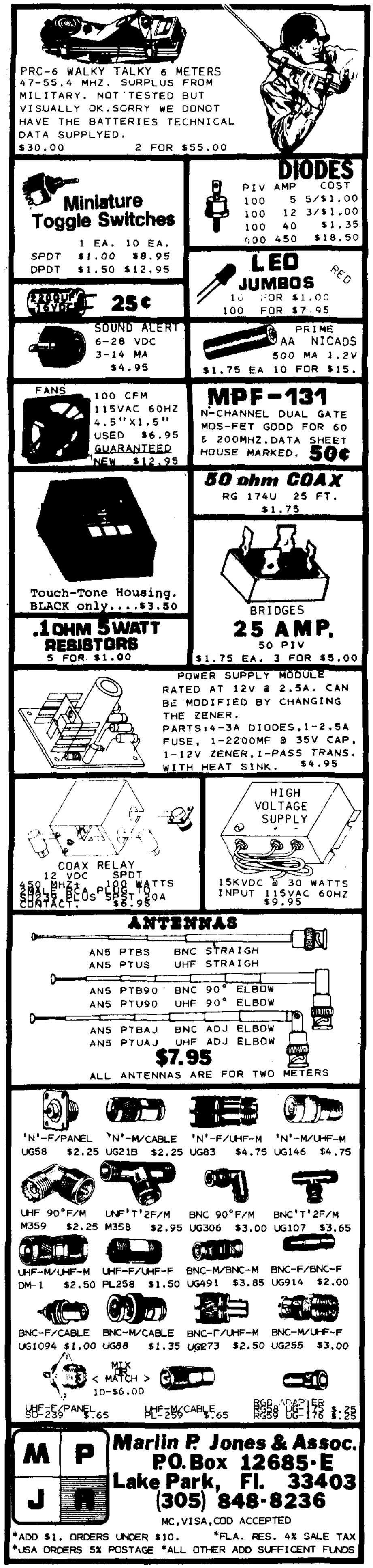

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Coming Events

MICHIGAN: Chelsea Swap and Shop, Sunday, June 1st, Chelsea Fairgrounds, Chelsea. Gates open 5 a.m. for sellers; 8 a.m. - 2 p.m. for public. Admission $1.50 advance, $2.00 at gate. Children under 12 free. Talk-in on 52 and 37/97. For more info write: William Altenberndt, 3132 Timberline, Jackson, MI 49201.

ONTARIO: Lake Simcoe Hamfest, June 13th, 14th and 15th, at Molson's Park, Barrie, Ontario, Canada. Registration: $4 by mail, $5 at gate. Children under 18 admitted free. Doors open at 12:00 noon on Friday the 13th, with talk-in on VE3LSR 146.25/.85 and 146.52 simplex, or 3780 kHz SSB. For information, reservations, or tickets, write to Lake Simcoe Hamfest, P.O. Box 2283, Orillia, Ontario L3V 6S1, Canada.

ILLINOIS: SRRC Hamfest, June 1st. Furnish large SASE for complete info. Starved Rock Radio Club — W9MKS/WR9AFG, RFD #1, Box 171, Oglesby, IL 61348. (815) 667-4614.

NEW YORK: Rochester Hamfest & NY State ARRL Convention. May 16-17. Add your name to mailing list. Send QSL to Rochester Hamfest, Box 1388, Rochester, NY 14603. Phone 716-424-1100.

CALIFORNIA: North Hills Radio Club's (K6IS) Sacramento Valley Amateur Radio Ham Swap, Sunday May 4th from 9 a.m. to 3 p.m., Machinists Hall, 3081 Sunrise Blvd., Rancho Cordova. Club auctions, swap tables, food and refreshments, raffles, grand prize: Kenwood TR-2400. Free admission. Talk-in on: 144.59/145.19 - 223.18/224.78. For information write: Ceil Pringle, WB6PBS, Box 701, Fair Oaks, CA 95628.

PENNSYLVANIA: The Ham-Mart sponsored by the Warminster Amateur Radio Club will be held on May 4th (Sunday), 9 a.m. to 4 p.m., rain or shine, at the William Tennet Intermediate High School, Warminster. Door prizes, FM clinic, auction, flea market, special drawing for Wilson 6 Channel hand held transceiver. Food and drink available. Admission $2.00, $3.00 for tailgaters (bring own table), $5.00/indoor table. Talk-in: 146.52 simplex, 146.16 - 146.76 PARA repeater. For more information write: W.A.R.C., Box 113, Warminster, PA 18974; or call Pat Cawthorne, W3DNI, (215) 672-5289.

INDIANA: Muncie Area Amateur Radio Club's Amateur Spectacular. Sunday, June 1, 1980, on Ball State University Campus. Over one acre of columnless, ground level, indoor space. Food prices of the 1960's. Thousands in awards. Forums: Computers, Traffic and Nets, The ARRL, etc. Talk in on 13/73, 223.30/224.90, 52/52. Advanced tickets $2.00, $3.00 at the door. Children under twelve free. For registration please contact, M.A.A.R.C., P.O. Box 3111, Muncie, Indiana 47302.

NEW ENGLAND: The Hosstraders net will hold its seventh annual Tailgate Swapfest, Saturday, May 10, at Deerfield N.H. fairgrounds (covered buildings in case of rain.) Admission $1.00, no commission or percentage. Excess revenues benefit Boston Burns Unit of Shriners' Hospital for Crippled Children. Last year we donated $1355.00. Questions about New England's biggest flea market? S.A.S.E to Joe, K1RQG, Star Route Box 56, Bucksport, ME 04416, or Norm, WA1IVB, P.O. Box 32, Cornish, ME 04020.

CALIFORNIA: 1980 Santa Maria Swapfest and BBQ, Sunday, June 15th. Best steak and biggest hamfest in the west. Prizes include the Yaesu FT-707. Swap tables available. QLF and QBK contests. Tickets $7 adults, $3.50 children 6-12. Write Santa Maria Swapfest, P.O. Box 1615, Vandeberg AFB, CA 93437 or call KA6AKC (805) 734-1380.

PENNSYLVANIA: Sixth Annual Northwestern Pennsylvania Hamfest. May 3, Crawford County Fairgrounds, Meadville. Note date change. Gates open 8 a.m. Bring your own tables. $5 per table to display inside, $2 per car space outside. $3 admission, children under 12 free. Refreshments. Commerical displays welcome. Talk in 04/64, 81/21, 63/03. Details C.A.R.S, P.O. Box 653, Meadville, PA 16335. Attn: Hamfest Committee.

MARYLAND: The Easton Amateur Radio Society's Hamfest, May 18th, 10 a.m. to 4 p.m., Easton Senior High School cafeteria, Easton. Donation $2.00; $4.00 for tables or tailgaters. Talk-in: 52 simplex, 146.445/147.045 repeater in Easton. For into write: R.C. Thompson, KA3BKW, Box 1473, Easton, MD 21601 or E.A.R.S., Box 781, Easton, MD 21601.

INDIANA: Wabash County ARC Hamfest, May 18th starting at 6 a.m. at the 4H Fairgrounds, Wabash. For more info write: Larry Manning, W.C.A.R.C., 235 Southwood Dr., Wabash, IN 46992.

MICHIGAN: Wexaukee Amateur Radio Association's Swap Shop, Saturday, May 17th, 9 a.m. to 4 p.m., at the National Guard Armory, Cadillac. Tickets $2; door prizes, free parking, lunches available. Talk-in on: 146.37/97. Write WD8RZL, P.O. Box 163, Cadillac, MI 49601.

MINNESOTA: The North Area Repeater Association's Amateur Fair, May 31st, Minnesota State Fairgrounds, St. Paul. Free overnight parking of self-contained campers on May 30th. Admission $3.00. Talk-in on: 16/76 and 52. For info and reservations write: Amateur Fair, P.O. Box 30054, St. Paul, MN 55175.

NORTH CAROLINA: Durham F.M. Association's annual Durhamfest, May 17 & 18, South Square Mall, Durham. Prizes, flea market, free tailgating, overnight parking, F.C.C. exams, free admission, Sunday bingo for the family. Tables, power available. $3.00 admission, including dealers. Talk-in: 147.825/225, 146.34/94, 222.34/94. For information: Durhamfest, Box 8651, Durham, NC 27707.

NEW JERSEY: The DeVry Tech Amateur Radio Club will hold its Flea Market on Saturday, May 17th at the DeVry Technical Institute, 479 Green St., Woodbridge. Space is $3.00, free admission. Talk-in on 146.52.

NEW YORK: The ARRL Hamfair '80 is being sponsored by the Long Island Mobile Amateur Radio Club on May 18th, 9 a.m. to 4 p.m., at the Islip Speedway, Islip, Long Island (exit 43 off the Southern State Parkway). ARRL info, door prizes, free parking - no reservations needed. Admission $2.00, exhibitors $4.00/space. Refreshments available at track. For further information contact (at night): Sid Wolin, K2LJH, (516) 379-2861 or Hank Wener, WB2ALW (516) 484-4322. Rain date: June 1st.

MARYLAND: Maryland FM Association's third hamfest, Saturday May 24th, 8 a.m. to 4 p.m. at the Greenbelt Armory, Greenbelt. Cash prizes, catered food, indoor displays & flea market, outdoor tailgating area. Talk-in on 52.525 simplex, 146.16/76, 146.28/88, 146.52 simplex, 449.1/444.1. Donations $3.00, tailgating $2.00, tables, $5.00. For further information write: Fred Siebert, K3PNL, 8357 Reservoir Rd., Fulton, MD 20759.

FLORIDA: The Daytona Beach Family Funfest will be sponsored by the Daytona Beach Amateur Radio Association on May 31st and June 1st, at the Desert Inn, Daytona Beach. Commercial exhibits, swap tables, door prizes, ladies activities, auction. Admission, $3.00 advance, $4.00 at door. Swap tables $8.00 for both days. For more information write or call: Dave Rusler, WA4ZTT, 1725 Hope Dr., Ormond Beach, FL 32074. (904) 672-9536.

More Details? CHECK—OFF Page 94

NEW YORK: Poughkeepsie Amateur Radio Club is celebrating "Morse Day" Sunday, May 18 from 9 a.m. to 9 p.m. EST, "Locust Grove", Poughkeepsie. The club station, K2KN will operate on CW and Phone, on HF bands 80 through 10 meters, and on 2 meter Phone on 146.52 MHz. For special QSL cards send legal size S.A.S.E. to: P. O. Box 3070, Poughkeepsie, NY 12603.

HOLLYWOOD AMATEUR RADIO CLUB'S 10TH ANNIVERSARY QSO PARTY — 1100 UTC May 24 to 1900 UTC May 24, 2300 UTC May 24 to 0700 UTC May 25, 1500 UTC May 25 to 2359 UTC May 25. Frequencies: CW - .070 up from each band edge and Novice bands; PH - 3.980, 7.280, 14.280, 21.380, 28.580. Exchange: (members) RST, consecutive serial number; non-members - RST, state, province, country. Copies of logs should be mailed to: Bob Patten, N4BP, 2311 Nassau Dr., Miramar, FL 33023 by June 20th. HARC members include dupe sheets for entries of over 500 QSO's.

COLORADO: The Northern Colorado Amateur Radio Club's Superfest II (Colorado Hamfest), June 7th, Weld County Exhibition Building, Greeley. Exhibits, talks, contest, auction, baby sitting and food service provided. Featured will be a Satellite TVRO terminal. Swap tables free with $3.00 admission. For further information contact: Gus Fox, WØEE, Box 895, Greeley, CO 80632. Talk-in on 146.25/85 and 146.52.

PENNSYLVANIA: Reading Radio Club Hamfest, Sunday, May 25th, Hamburg at the fieldhouse. Take Rt. 22 from east or west, Rt. 61 from north or south. Huge indoor plus outdoor site, no weather worries. Many cash and equipment prizes. Talk-in 146.31/91, 146.52. Info: W3BN, P.O. Box 124, Reading, PA 19603.

WASHINGTON: Yakima Amateur Radio Club's (W7AQ) Hamfest, Sunday, May 18th, Yakima. Breakfast (at 7 a.m.), lunch, prizes, swap shop, new product dealers. Talk-in on 34-94, 25-85, 01-61. For more information contact: Ken Zahn, KA7DWH, 4 North 16th Ave., Yakima, WA 98902.

CONNECTICUT: Dogwood Festival QSO Party sponsored by the Greater Fairfield Amateur Radio Assoc., 1300-2200 UTC May 17th. To work WB1CQO check SSB frequencies: 3975, 7235, 14.330, 21.420, 28.710. FM: 146.55 simplex. For special QSLs send SASE or IRCs to: Grace von Stein, 248 Euclid Ave., Fairfield, CT 06432.

1980 FLORIDA QSO PARTY sponsored by Florida Skip, 1500 UTC May 17 to 2359 UTC May 18. All amateur bands may be used — submit separate Phone and CW logs. Florida stations send signal report and county of operation. Out-of-state stations send signal report and U.S. State, Canadian province or country. Suggested frequencies: CW — 3555, 7055, 14055, 21055, 28055. Phone — 3945, 7279, 14319, 21379, 28579, 50.2, 146.52. For more info write: W4MNZ. Deadline for entries: June 15th. Mail to: Florida Skip Contest Committee, Box 660501, Miami Springs, FL 33166.

CALIFORNIA: 25th Annual West Coast VHF Conference, May 9th through 11th 1980, Miramar Hotel, Santa Barbara, California. Hospitality room, technical sessions, special programs, noise figure measurements, antenna gain measurements, technical exhibits, prizes, drawings! Special convention rates (write directly to Miramar Hotel, Box M, Santa Barbara, California 93102 for room reservations). Pre-registation $4 per person until May 1st, $6 at door. Make checks payable to the West Coast VHF Conference, and mail to Wayne Overbeck, N6NB, 5818 Woodlake Avenue, Woodland Hills, California 91367.

GERMANY: Hamfest sponsored by Wiesbaden A.R.C. and DOK F20 club, starts 10 a.m., Sunday, May 4th, Auringen (5Km north of Wiesbaden). Talk-in 145.55 MHz, follow signs on major autobahns. Flea market, vendors, displays, demonstrations, technical assistance, left-foot CW contest, prizes, food and beverages. For information, write Stephen Hutchins, DA2HS/WD6BKA, Box 4573, APO New York 09109.

DXPEDITION: Liechtenstein, 23 May - 31 May 1980. Callsign DA1WA/HBØ. Frequencies: Phone — 3780, 7090, 14280, 21350, 28650; CW — up 25 kHz from bottom end of band. *Stateside:* QSL and SASE (15¢) by regular U.S. Mail to Stephen Hutchins, Box 4573, APO NY 09109. *All others*, QSL via Hugo Jakobljevich, DJØLC, Am Weinberg 10, 6201 Auringen, West Germany.

"DXPEDITION": Law West of the Pecos fun DX-pedition, 1800 GMT Saturday, April 19 to 1800 GMT Sunday, April 20th. Frequecies: SSB — 7235, 14285, 21360; CW — 21110; Callsign: W5TEX. QSL and SASE to LWPDX, 2618 Rigsby Avenue, San Antonio, TX 78222.

ROCKY MOUNTAIN DIVISION QSO PARTY sponsored by the Arapahoe Radio Club, 1800Z May 10th to 2400Z May 11th. Stations exchange RS(T) and ARRL section. Suggested frequencies: 3560, 7060, 14060, 21060, 28060, 3900, 7270, 14300, 21370; novice: 3725, 7125, 21125, 28125. Submit logs with large SASE by June 15th to: KAØCLS, 8973 W. Harvard Dr., Lakewood, CO 80227.

More Details? CHECK—OFF Page 94

THE 1980 MASSACHUSETTS QSO PARTY sponsored by The Greater New Bedford Contesters, 1600 GMT May 17th to 0200 GMT May 19th. A station may be worked once per band. FONE and CW are separate bands. Frequencies suggested: CW — 1810, 3.560, 7.060, 7.120, 14.060, 21.060, 21.120, 28060, 28.120. FONE — 1820, 3.960, 7.260, 14.290, 21.390, 28.590, 50.110. For info and results write: K1KJT, Ed Peters, 29 Greenbrier Dr., New Bedford, MA 02745.

GEORGIA QSO PARTY Sponsored by the Atlanta Radio Club, 1600 GMT May 10th to 0200 GMT May 12th. Exchange: QSO number, RS(T), and QTH, county, province, or country. Georgia to Georgia contacts permitted. Frequecies: CW — 1.805, 3.590, 7.060, 14.060, 21.060, 28.060. SSB — 3.900, 7.245, 14.290, 21.360, 28.600. Novices: 3.718, 7.125, 21.110, 28.110. For info write: Atlanta Radio Club, Inc., c/o John Jones, WD4OPT, 1671 Bristol Dr., Atlanta, GA 30329. Logs must be postmarked by June 1st.

MICHIGAN 1980 QSO PARTY sponsored by the Oak Park Amateur Radio Club, 1800 May 17th to 0300 May 18th, and 1100 May 18th to 0200 May 19th. Phone and CW combined into one contest. Frequencies: CW — 1810, 3540, 3725, 7035, 7125, 14035, 21035, 21125, 28035, 28125; Phone — 1815, 3905, 7280, 14280, 21380, 28580; VHF — 50.125, 145.025. Mailing deadline June 30 to: Mark Shaw, K8ED, 3810 Woodman, Troy, MI 48084.

RADIO EXPO "80" Lake County fair grounds, Rt. 45 & 120. Sept. 6 & 7 — advanced tickets $2.00, $3.00 at gate. Write: Radio Expo Tickets, P.O. Box 1532, Evanston, IL 60204. Exhibitor information call (312) BST-EXPO.

ALABAMA: The Birmingham Amateur Radio Club's BirmingHAMfest '80 will be held on May 17th & 18th at the Birmingham-Jefferson Civic Center Exhibition Hall. Exhibitors, flea market, prizes, and special guest speaker at banquet — Archie Campbell from t.v.'s Hee-Haw. For tickets and information write: BirmingHAMfest '80, P.O. Box 603, Birmingham, AL 35201.

RHODE ISLAND: The Newport County Radio Club will hold an auction at the Seamens Institute, 18 Market Sqaure, Newport on May 5th at 7 p.m.

MASSACHUSETTS: Hampden County Radio Association's Flea Market will be held on Friday, May 2nd at 7 p.m., at the Feeding Hills Congregational Church, Feeding Hills. No admission charge, $3.00/seller's table. Contact Andy Bouchard. WB1BZW for more information at: (413) 786-2301.

MASSACHUSETTS: The Bristol County Amateur Radio Association's Flea Market and Radio Auction will be held on Sunday, may 4th from 9 a.m. to 5 p.m., at the Knights of Columbus Hall in Fall River. Talk-in on 146.31/91. For more information write: AA1Q.

NEW JERSEY: The Tri-County Radio Association's indoor Hamfest/Flea Market will be held at the Passaic Township Youth Center, Valley Rd., Stirling, on Sunday, May 4th from 9 a.m. to 4 p.m. Admission, $2.00, tables, $5.00. Many door prizes. Talk-in on 147.855/.255 or 146.52. For information write: TCRA, Box 412 Scotch Plains, N.J. 07076 or call Herb, W2CHA at (201) 647-3461.

MICHIGAN: Central Michigan Amateur Repeater Association's Swap & Shop, Midland, June 21st, at the Midland County Fairgrounds. Computer demonstrations, door prizes. Talk-in on: 146.73 WR8ARB and 146.52 simplex. Tickets and info SASE to: R.L. Wert, W8QOI, 309 E. Gordonville Rd., R#12, Midland, MI 48640.

INDIANA: The Lake County Amateur Radio Club's Dad's Day Hamfest, June 15th, Lake County Fairgrounds, Crown Point. Tickets $1.50 in advance, $2.00 at door. Talk-in 147.84/24 or 146.52 simplex. For tickets and information write: Tickets, P.O. Box 1909, Gary, IN 46409.

OHIO: Sandusky Valley Amateur Radio Club's Hamfest, May 25th, beginning at 7 a.m. at the Sandusky County Fairgrounds. All tables free, admission $1.00. Talk-in: 52/52, 146.31/91. For tickets and info send SASE to: Ron Winkle, WB8NMK, 1200 Stilwell Ave., Fremont, OH 43420.

MAINE: A Flea Market sponsored by the Portland Amateur Wireless Assoc. and the University of Southern Maine Radio Club, May 24th, Gorham-Maine campus of University of Maine, Gorham. Time: 9 a.m. to 5 p.m. Indoor & outdoor sites available. Admission $1.00. Talk-in: 52, 73, 06. For further info: Jon Taylor, 44 Mitton St., Portland, ME 04102, or call (207) 773-2651.

MICHIGAN: The Ford Tin Lizzy Club, North Metro Chapter's "Tip-Of-The-Thumb" Expedition, Point Aux Barques reef, 2200Z May 16th through 1400Z May 18th. Primary frequencies: 7.275 and 21.380 MHz. For QSLs write: AJ8K.

MISSOURI: Amateur Radio and Computer Hobbyists Convention sponsored by the Gateway Amateur Radio Assoc., on May 24-25th, Cervantes Convention Center, St. Louis. Many special events planned — for further information write: Gateway Amateur Radio Assoc., Box 68, Marissa, IL 62257.

More Details? CHECK—OFF Page 94

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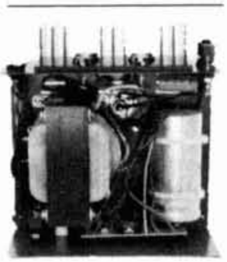

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European amateurs: please contact Ham-Radio, Postfach 120, CH-5702, Niederlenz, in Switzerland, and Ingoimpex, Postfach 24 49, D-8070, Ingolstadt, West Germany, for the rest of the continent.

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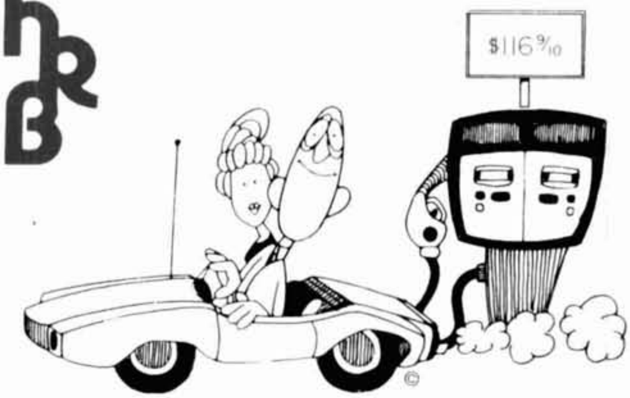

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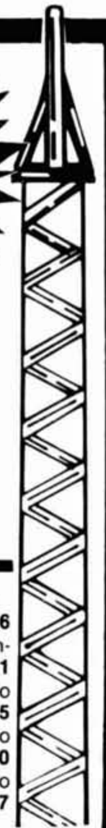

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